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Uncover their aims and their view of the Martian stars

#189 FEBRUARY 2021

Sky at Night

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NEW YEAR SPECIAL

2021'S STARGAZING HIGHLIGHTS

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Welcome

We look ahead to a year of stargazing opportunities!

The New Year may not have started the way we'd have wanted, but there is a spark of solace: the promise of long, dark nights ahead under the cosmos, observing the silent celestial sphere. For me, stargazing provides a lift from the labours of day-to-day life, and a reminder that the natural world – in its grandest of forms – keeps on going.

There is lots to look forward to in the night sky in 2021, and on **page 28** Jamie Carter guides us through the top stargazing events to look out for over the next 12 months. Expect stunning conjunctions, the return of familiar favourites and eclipses both lunar and solar ahead!

The science of astronomy continues too, and in February we see the arrival of three new missions at Mars. On **page 62** Stuart Atkinson looks at the view these missions will have of the Red Planet's night sky (with the help of images from previous Mars visits) and considers whether it's one that human eyes will witness in the future.

However, the path of space exploration often doesn't run smoothly, and scientists and engineers have to overcome unexpected challenges. On **page 68**, Ezzy Pearson takes a look at some of the occasions when the mission trajectories of rovers and space probes were sent off course by factors as peculiar as a lack of refreshments and the game of cricket.

Lastly, the Astronomy Photographer of the Year 2021 competition is open for entries. You'll find details on **page 40**, and inspiration for one of the competition's newest categories, the Annie Maunder Prize for Image Innovation, on **page 34** courtesy of Will Gater, who speaks to the professionals creating the imagery for the biggest space stories.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 18 February.

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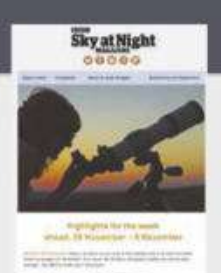
Sky at Night – lots of ways to enjoy the night sky...



Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

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CONTENTS

C = on the cover

Features

28 A guide to stargazing in 2021
C We pick 21 of the best sights to observe, from constellations to eclipses and much more

34 Picturing space
C Meet the artists who create stunning visualisations of space

40 APY 2021 opens
The prestigious astrophotography contest is open for your entries

62 The Red Planet's sky at night
C What views of the Martian night sky will visiting missions observe?

68 The strange world of
C robotic space exploration
Discover the ups and downs of the trailblazing robot missions

Regulars

6 Eye on the sky
11 Bulletin
16 Cutting edge C
18 Inside *The Sky at Night*
20 Interactive
23 What's online
25 Field of view
26 Subscribe to *BBC Sky at Night Magazine*
60 Explainer
74 DIY Astronomy
98 Q&A: a Europa expert C

Astrophotography

76 Capture
78 Processing
80 Gallery

Reviews

86 Atik ACIS 7.1 CMOS mono camera
90 Sky-Watcher Star Discovery P150i Wi-Fi telescope
94 Books
96 Gear

The Sky Guide

16-PAGE CENTRE PULLOUT

44 Highlights
46 The big three C
48 The planets
50 February's all-sky chart
52 Moonwatch
53 Comets and asteroids
53 Star of the month
54 Binocular tour
55 The Sky Guide challenge
56 Deep-sky tour
58 February at a glance

COVER MAIN IMAGE: DZIKA_MROWKA/ISTOCK/GETTY IMAGES. THIS PAGE: EERIK/ISTOCK/GETTY IMAGES, X-RAY: NASA/CXC; UV/OPTICAL: NASA/STSCI; COMBINED: NASA/ESA/N. SMITH (UNI OF ARIZONA)/J. MORSE (BOLDLYGO INST), A. PAGAN, NASA/JPL/TEXAS A&M/CORNELL, PETE LAWRENCE, @THESHED_PHOTOSTUDIO, STOCKTREK IMAGES, INC/ALAMY STOCK PHOTO, BBC

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Jamie Carter

Astronomy journalist

"2021 will bring Venus as an 'Evening Star' and a perfectly timed Perseid meteor shower, but it's the partial solar eclipse on 10 June that most excites me!" **Jamie looks at 2021's stargazing highlights,** page 28

Shaoni Bhattacharya

Science journalist

"Hearing about Jupiter's 'glow-in-the-dark' moon fired my imagination and made me wonder if one day humans really could find a home in Europa's interior". **Shaoni meets NASA's Dr Murthy Gudipati,** page 98

Mary McIntyre

Outreach astronomer

"It was a challenge designing a stylish yet educational model of a comet using household items. I hope you love the result as much as I do." **Mary shows you how to make an educational model of a comet,** page 74

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/7CXVMDT/** to access this month's selection of exclusive Bonus Content

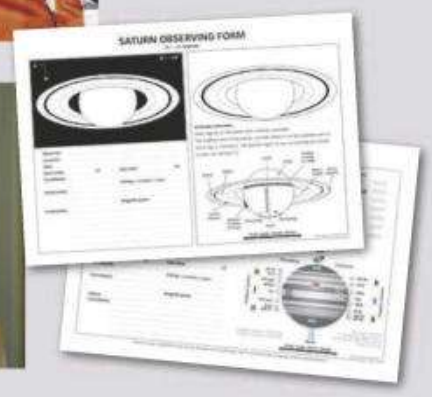
FEBRUARY HIGHLIGHTS

Interview with a spaceflight professional

Aerospace expert and suborbital scientist Kellie Gerardi discusses the secrets of the commercial space industry, how we can democratise access to space, and getting human feet on the Moon and Mars.

The Sky at Night: State of Astronomy

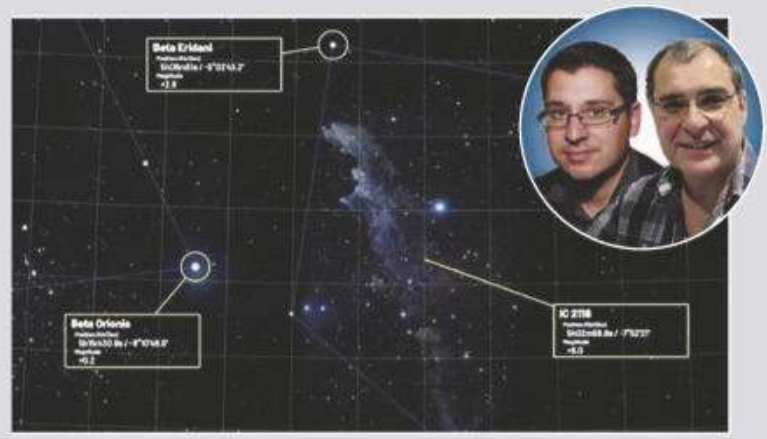
Chris and Maggie join an illustrious group of the UK's best astronomers to pick their top moments from the past decade.



Download observing guides and charts

Access planet observing forms, binocular and deep-sky tours and our guide to Southern Hemisphere stargazing.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

CURVE APPEAL

Hubble reveals the largest nearly complete Einstein ring

HUBBLE SPACE TELESCOPE, 14 DECEMBER 2020

Nicknamed the Molten Ring, the 'curved' galaxy in this Hubble Space Telescope image is GAL-CLUS-022058s, located in the southern constellation of Fornax, the Furnace.

The largest and one of the most complete examples of an 'Einstein ring' ever discovered, it beautifully illustrates the phenomenon of gravitational lensing predicted by Einstein in his general theory of relativity.

The arcing effect of lensing is produced when the gravity of a massive galaxy cluster distorts the light from more distant galaxies behind it. The key factor here is us: the effect only arises because, to our line of sight (or more accurately, the Hubble Space Telescope's), the two objects are in the same line of sight. Gravitational lensing can produce distorted, magnified and even multiple images of the background object, and is an indispensable tool for detecting the mass of unseen planets and stars.

MORE **ONLINE**

A gallery of these and more stunning space images

ESA/HUBBLE & NASA/S. JHA/ACKNOWLEDGEMENT: L. SHATZ

INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/NSF/AURA, SOHO (ESA & NASA), INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/NSF/AURA, CTIO/NOIRLAB/NSF/AURA

◁ The Inbetweener

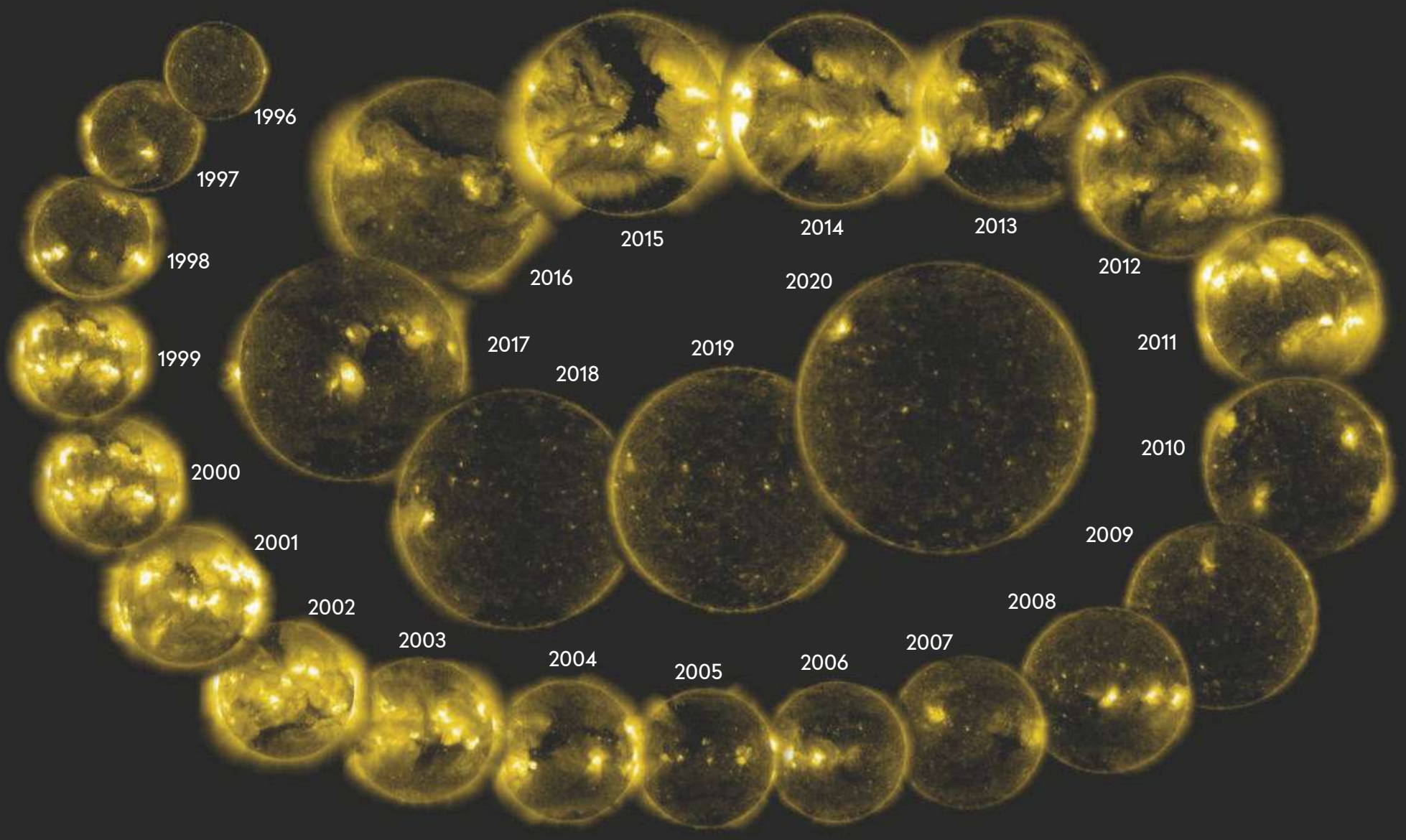
GEMINI NORTH, 24 NOVEMBER 2020

This nebula, CK Vulpeculae, keeps astronomers guessing. A bright new star seen in 1670, it was first thought to be the collision of two main-sequence stars, and more recently an encounter between a white and brown dwarf. Now evidence shows the nebula is expanding five times faster than previously thought, putting it in an enigmatic class of novae known as Intermediate Luminosity Transient Objects.

▽ Sun worshipper

SOLAR AND HELIOSPHERIC OBSERVATORY (SOHO), 2 DECEMBER 2020

This montage marks 25 years of the ESA and NASA Solar and Heliospheric Observatory (SOHO). Originally slated for a two-year mission, since its launch in 1995 the spacecraft's Extreme Ultraviolet Imaging Telescope has observed two 11-year solar cycles and discovered over 4,000 comets.



△ Taking centaur stage

GEMINI NORTH, 9 DECEMBER 2020

Occupying an unstable orbit between Jupiter and Neptune, this object is a 'centaur' on its way to a new life. The icy cousins of comets and asteroids, centaurs can either shoot out of the Solar System altogether or, like P/2019 LD2 (ATLAS) here, become a Jupiter Family Comet. Its tail growing as it nears the Sun, the small Solar System body is likely to fall into orbit around Jupiter within 40 years.

On reflection ▷

CERRO TOLOLO INTER-AMERICAN OBSERVATORY, 25 NOVEMBER 2020

Hot stars light up dusty clouds in blue pulses, as they shine like bright hearts nestled in glowing red clouds of warm hydrogen gas. This is the region around reflection nebula NGC 2170, captured by the SMARTS 0.9m telescope at Chile's Cerro Tololo Inter-American Observatory.

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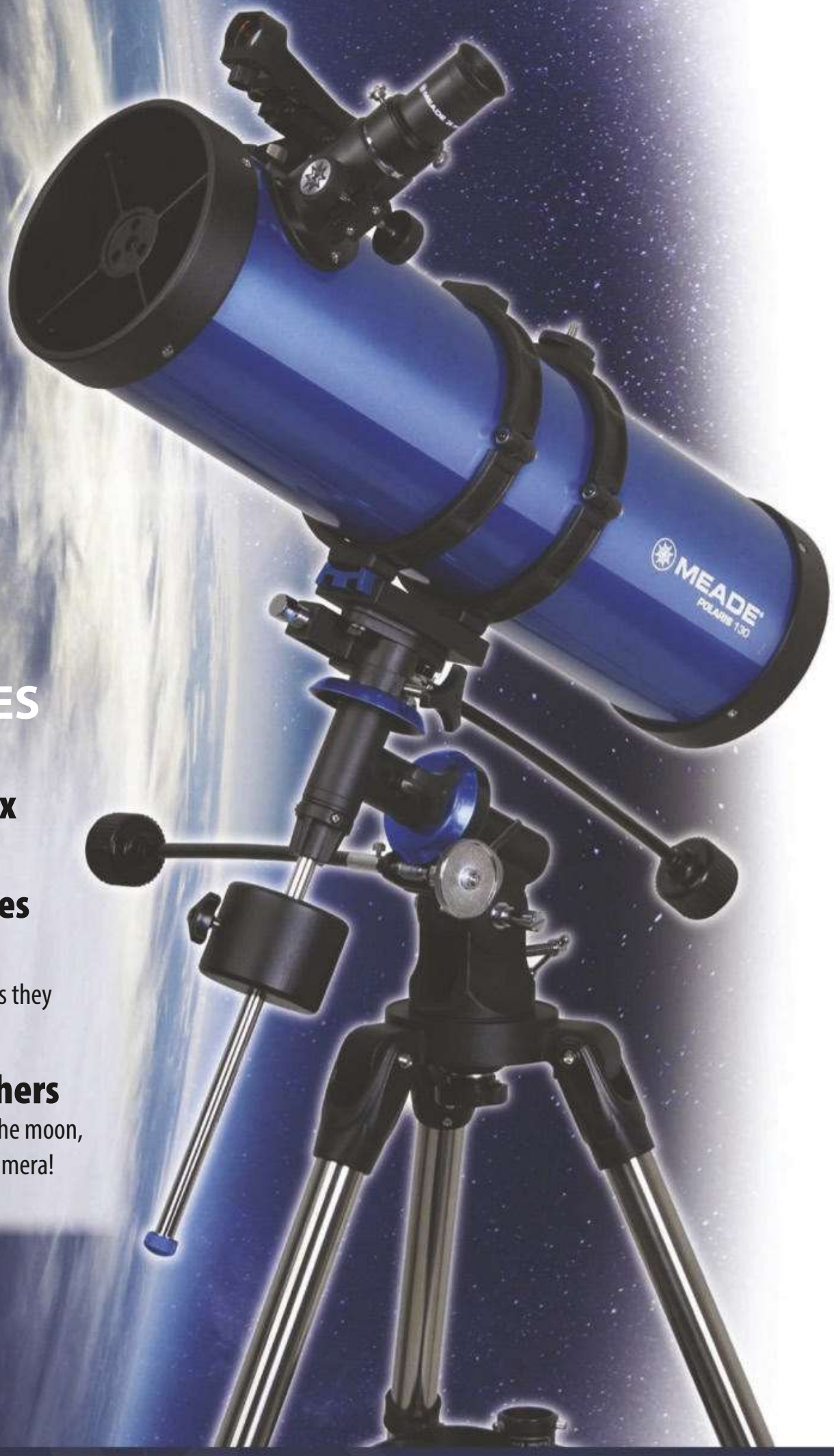

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The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

▲ **While Japan's Hayabusa 2 (top) mission returned from asteroid Ryugu with a 5.4g rock sample, China's Chang'e 5 mission to the Moon (below) has brought back 1.7g of lunar material**

JAXA, VCG/CONTRIBUTOR

It's raining space rocks

Two Asian nations succeed in sample return missions for the first time

Not one, but two samples of pristine space rock made their way back to Earth in December 2020 – one from an asteroid, another from the Moon. It's the first time such a mission has been a success in almost 15 years.

The first to arrive back was Hayabusa 2, a Japanese spacecraft that returned from asteroid Ryugu on 5 December, after a year-long journey back to Earth. The spacecraft crashed landed in the Woomera Prohibited Area near Adelaide in Australia. The Japanese space agency, JAXA, quickly located the return capsule by its radio signal and transferred it to the Extraterrestrial Sample Curation Center in Japan. Here the team were able to open up the sample canister without risk of terrestrial contamination and could collect any volatile gases that had boiled off upon reaching Earth. The spacecraft has recovered 5.4g of material – the first time such a substantial amount of space rock has been returned from an asteroid.

A few weeks later, another sample return – the Chinese Chang'e 5 mission – returned from the surface of the Moon, landing in the Ulanqab region of Inner Mongolia. The mission had spanned less than a month, having left on 23 November, and returning on 16 December. But in that brief time the spacecraft managed to land on the Moon, scoop up 1.7kg of lunar material, relaunch and return to Earth.

This is the first time either of the nations has successfully accomplished a sample return mission, marking out both as powerhouses in the field of planetary exploration.

www.hayabusa2.jaxa.jp/en

Comment

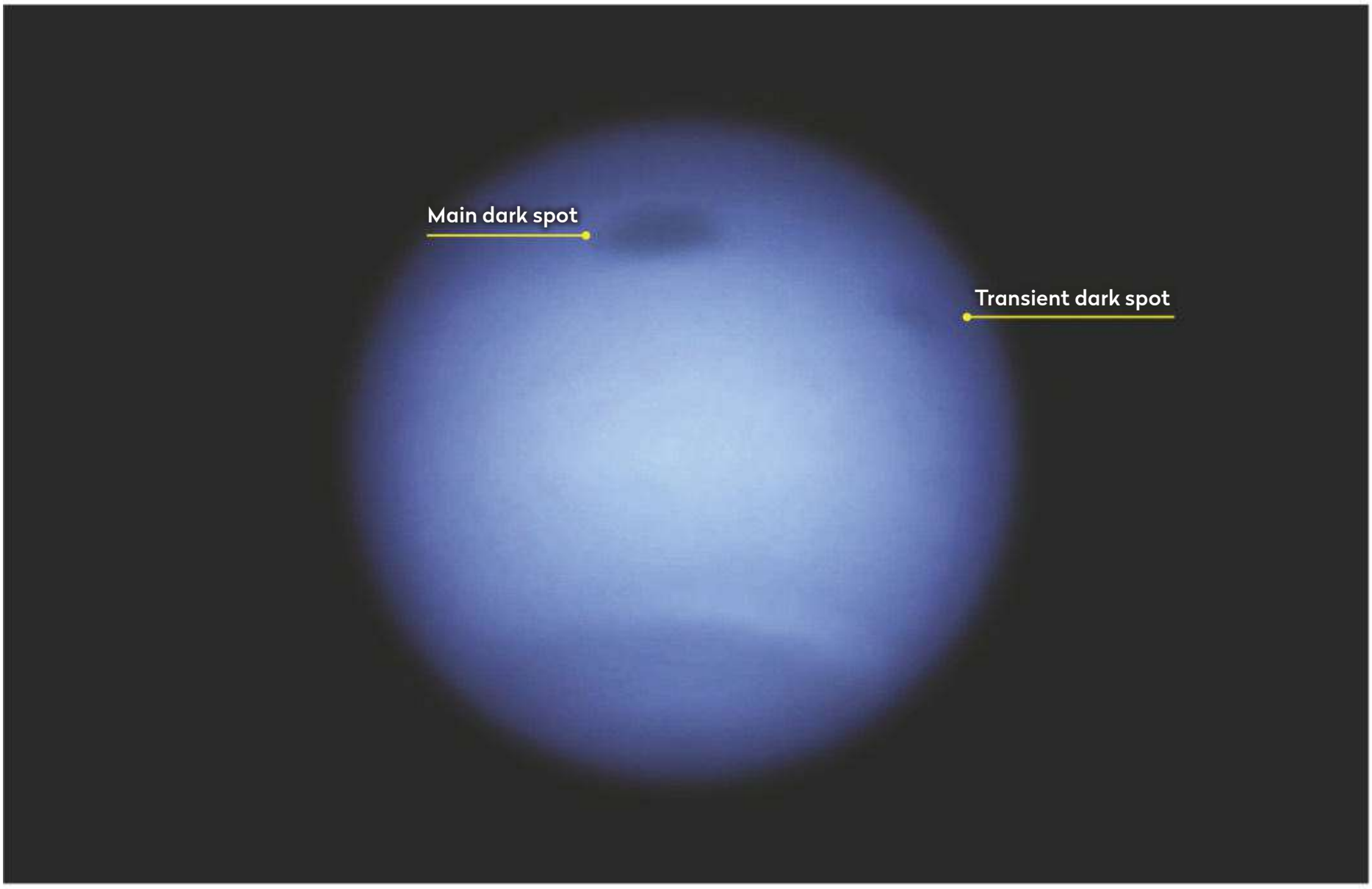
by Chris Lintott

Any robotic mission that explores the Solar System is a marvel of miniaturisation, but there are limits to what can be achieved. By returning a sample to Earth, a full arsenal of scientific techniques can be deployed.

The return of Hayabusa 2 means Ryugu joins an exclusive club – apart from the Moon, we only have a few micrograms of asteroid Itokawa, from the troubled first Hayabusa, and a little of Comet Wild, gathered by NASA's Stardust.

Chang'e 5's lunar haul is still only the 10th sample to make it back. Even a pinch of dust from its payload can transport us to the volcanoes of the Oceanus Procellarum. Scientists will be eagerly awaiting their arrival.

Chris Lintott co-presents *The Sky at Night*



▲ **Neptune's stormy dark spot has a smaller companion nicknamed Dark Spot Jr, but it remains a mystery whether the two are related**

Neptune's storm dodges its demise

A change of direction stopped the storm from straying to the planet's calm equator

It continues to be a dark and stormy time on Neptune, as a 7,400km-wide storm has saved itself from destruction, it was recently revealed. And it may have created a smaller companion in the process.

The Hubble Space Telescope has been watching the dark spot created by the storm move south towards the planet's equator since it was discovered in 2018. Such storms are thought to be kept stable at mid-latitudes by the Coriolis force, which is created by the planet's spin. As this force is weaker at the equator, storms tend to blow themselves out when they drift into the region, so the observing team were expecting to watch the dark patch disappear.

Instead, in August 2020 the team noticed the storm had taken an abrupt turn northwards, sparing itself this untimely demise. No one has seen this kind of storm behaviour in the outer planets before.

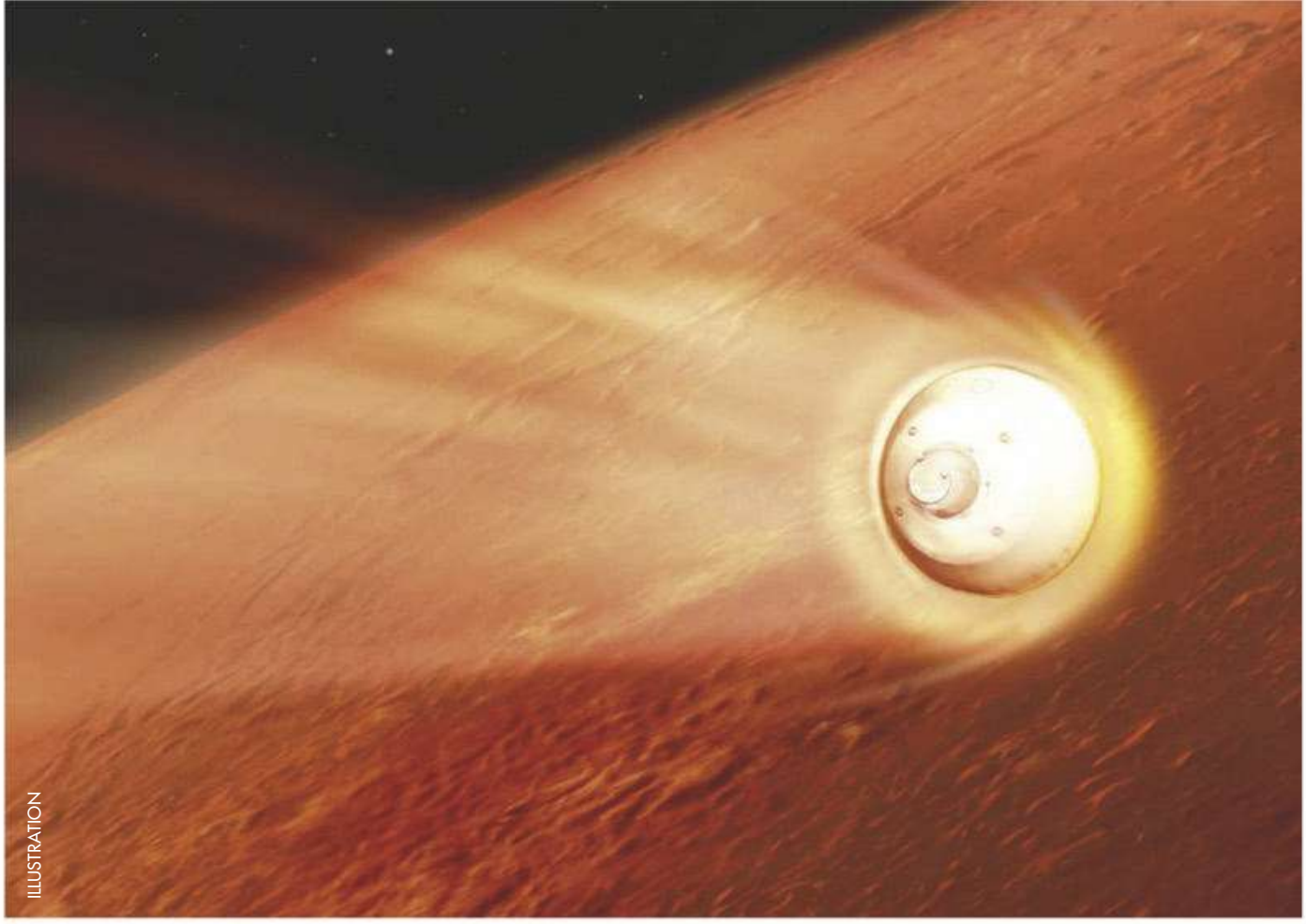
"It was really exciting to see this one act like it's supposed to act, and then all of a sudden it just stops and swings back," said Michael H Wong from the University of California at Berkeley, who took part in the study. "That was surprising."

Even more surprisingly, Wong and his fellow astronomers also noticed that a second, smaller transient dark spot had appeared near the storm's equator-facing side, which they nicknamed 'Dark Spot Jr'.

"When I first saw the small spot, I thought the bigger one was being disrupted," said Wong. "I didn't think another vortex was forming because the small one is farther towards the equator, so it's within this unstable region. But we can't prove the two are related; it remains a complete mystery."

Although Hubble has seen many storms in the atmosphere of Neptune in the last 30 years, this one has been the most closely studied, as it's been watched as part of the Outer Planet Atmospheres Legacy (OPAL) programme. This initiative takes regular images of the four outer planets with Hubble, creating an archive of images tracking the planets through the years. Astronomers can then use this archive to see how the planetary atmospheres change over time.
https://archive.stsci.edu/prepds/opal

NASA/STSCI, NASA/JPL-CALTECH, NASA/GSFC/SDO, ESA-D. DUCROS/2013



▲ An artist's impression of NASA's Perseverance rover plunging through the Martian atmosphere

Robotic armada arrives at Mars

Three Martian missions make their start this month

It's almost time to begin invading the Red Planet, as spacecraft from three different nations complete their journeys this month.

The largest of these is NASA's Perseverance rover, due to land on the surface of Mars on 18 February. Once down, the rover will roam the Martian landscape, collecting caches of rocks that a future mission will pick up and return to Earth.

Meanwhile, two other nations are making their first trips to the planet. China is sending its Tianwen-1 mission; the spacecraft will stay in orbit for a few months to look at the planet from above, before it puts down a small rover.

Finally, the United Arab Emirates (UAE) is hoping to celebrate the arrival of its first ever planetary spacecraft, Hope. The orbiting spacecraft will arrive on 9 February with the goal of investigating the Martian atmosphere.

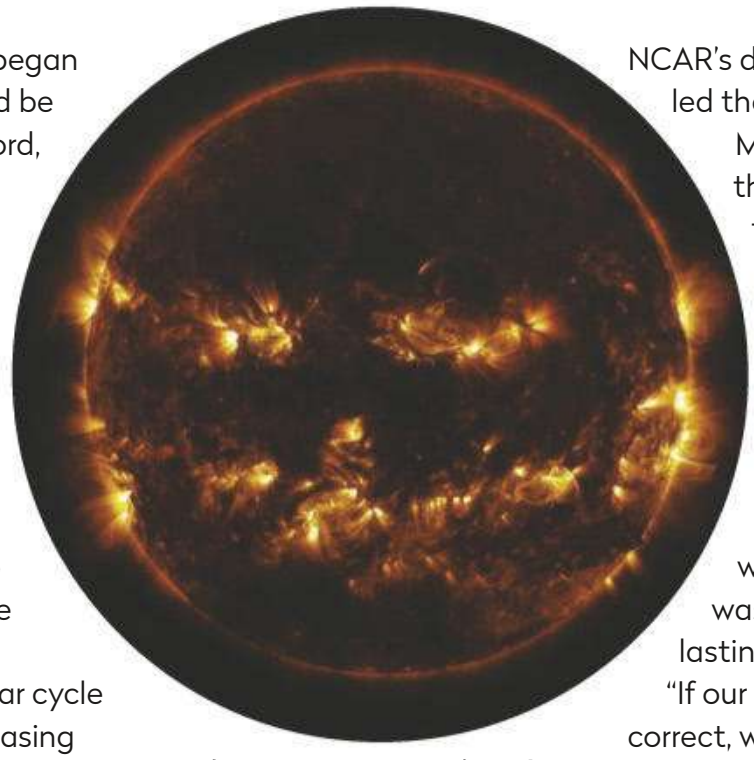
https://mars.nasa.gov

Current solar cycle could be strongest yet

Solar Cycle 25, which began in December 2019, could be the most active on record, if a new study is to be believed. The new prediction from the National Centre for Atmospheric Research (NCAR) is directly opposed to previous projections made by a panel of solar astronomers, who forecast it would be one of the weakest.

The Sun has an 11-year cycle of increasing and decreasing sunspot activity, driven by the Sun's magnetic field.

"Scientists have struggled to predict both the length and the strength of sunspot cycles because we lack a fundamental understanding of the mechanism that drives the cycle," says Scott McIntosh, NCAR's deputy director, who led the study.



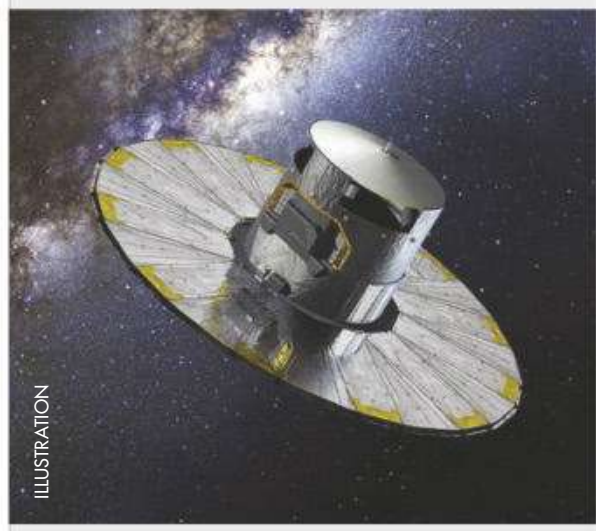
▲ 'Terminator events' on the Sun may hold clues about the lengths of solar cycles

McIntosh's team made the forecast by looking for 'terminator events', when bright spots from both poles meet at the equator. They found the shorter the gap on one cycle, the stronger the next was; Solar Cycle 24 was relatively short, lasting 10 years.

"If our forecast proves correct, we will have evidence that our framework for understanding the Sun's internal magnetic machine is on the right path," says McIntosh.

www.ucar.edu

NEWS IN BRIEF



Star database released

The positions of almost 2 billion stars have been made publicly available following the third release of data from the European Space Agency's Gaia satellite. As well as many distant stars, the new batch of information contains precise measurements of 300,000 stellar objects within 326 lightyears of the Sun.

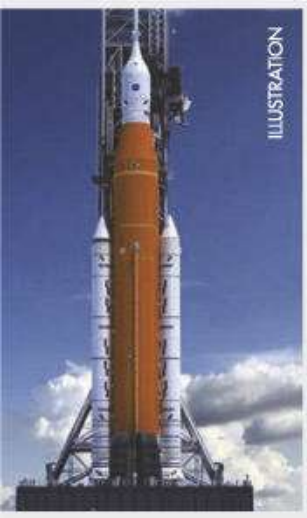
Starless planets

Two gas giant exoplanets, around 8 and 15 times the mass of Jupiter, appear to have formed in orbit around each other without a central star. The pair's large size and separation (around 200 times the Earth-Sun distance) suggest that they formed directly from interstellar gas, just like stars would.

Lightweight galaxies

Hubble has discovered two galaxies that appear to be completely devoid of dark matter. As dark matter has always been considered a key ingredient in pulling young galaxies together, astronomers are at a loss to explain how the pair came to be.

NEWS IN BRIEF



ILLUSTRATION

SLS timeline tightens

The first flight of NASA's Space Launch System (SLS) could be in jeopardy after a late-2020 rehearsal of its launch procedure up to 30 seconds before liftoff was held back by almost two weeks. The test was eventually successful, meaning it can still make its November 2021 launch date, but there is now little margin in the schedule.

Past asteroids were larger

Astronomers studying a meteorite that fell to Earth in 2008 believe it originated as part of an asteroid the size of Ceres – the largest asteroid in the belt between Mars and Jupiter. The find suggests there were once other large asteroids in the early Solar System, but they have been blasted apart by collisions with other space rocks.

Life ingredient found in mulitple meteorites

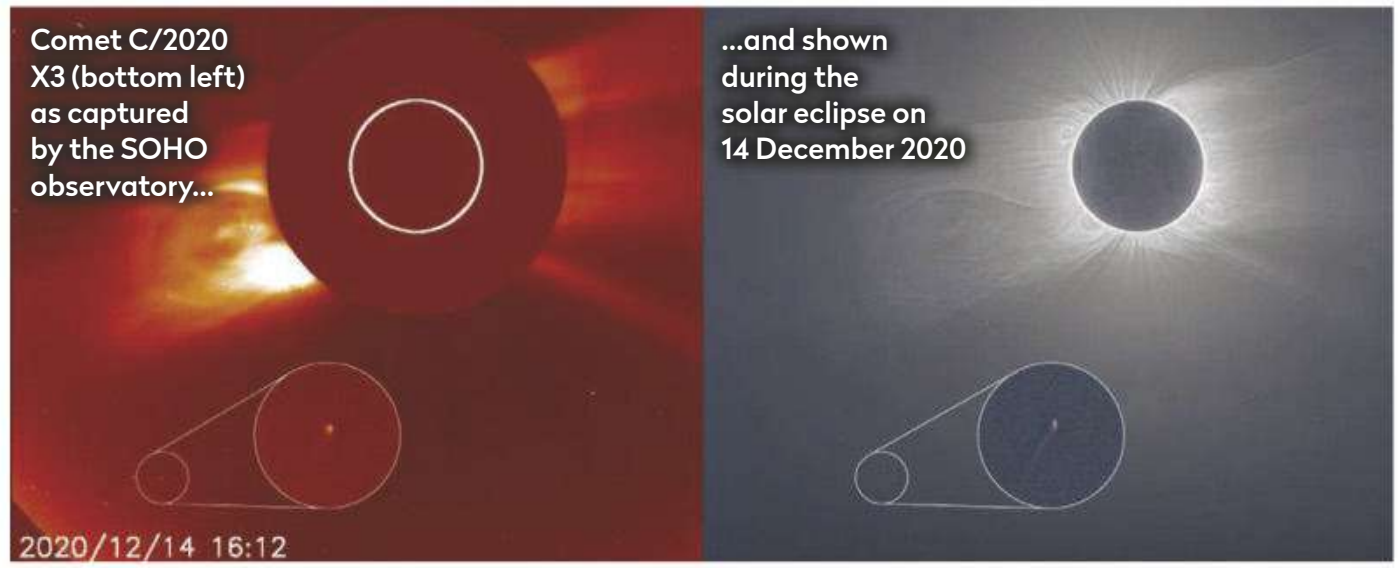
Chemists have discovered the presence of a key pre-biotic ingredient called hexamethylenetetramine, in three different meteorites. The discovery supports the theory that such chemicals were created in space during the Solar System's formation, and were then brought to Earth by asteroids.

NASA, ESA/NASA/SOHO/ANDREAS MÖLLER (ARBEITSKREIS METEORE E.V.)/PROCESSED BY JAY PASACHOFF AND ROMAN VANUR/JOY NG. ECLIPSE IMAGE USED WITH PERMISSION., NASA/SDO, NASA/ESA/B. BALICK (UNIVERSITY OF WASHINGTON) M. GUERRERO (INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA) AND G. RAMOS-LARIOS (UNIVERSIDAD DE GUADALAJARA)

BULLETIN

Short-lived comet spotted during eclipse

The celestial visitor was identified by a citizen scientist


Comet C/2020 X3 (bottom left) as captured by the SOHO observatory...
...and shown during the solar eclipse on 14 December 2020
2020/12/14 16:12

An amateur astronomer, Worachate Boonplod from Thailand, discovered a comet making its closest approach to the Sun on 13 December – just one day before a total eclipse. He discovered the icy body as part of a NASA funded citizen science initiative, the Sungrazer Project, which asks space enthusiasts to look at images from the Solar and Heliosphere Observatory (SOHO), searching for new comets.

With an eclipse due to grace the skies above South America the next day, Boonplod hoped that someone would be able to capture the tiny speck of the comet as it streaked towards the Sun around 724,000 km/h – which both SOHO and several astrophotographers did. The comet didn't survive its brush with the Sun however, as it disintegrated into dust just a few hours before it would have reached its closest approach.
https://sungrazer.nrl.navy.mil

Strong flares might not sterilise planets

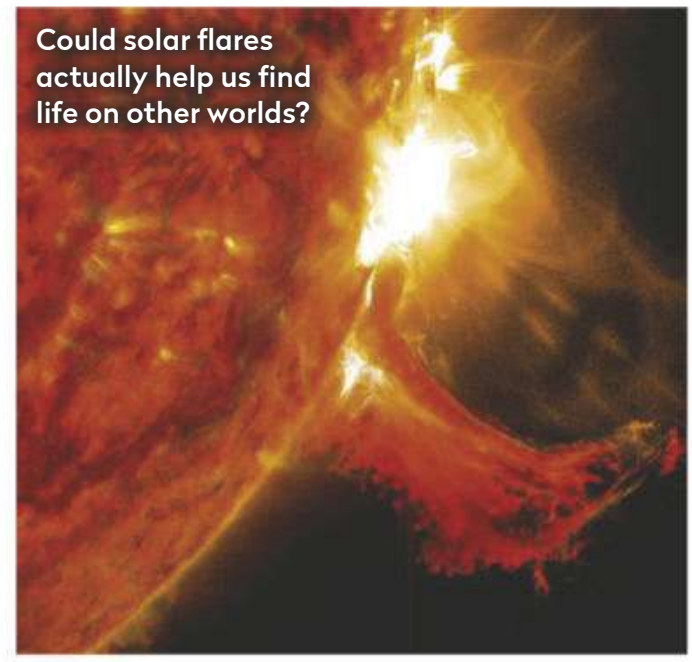
Planets around highly active stars which are throwing off solar flares might still have a chance at forming life, a study has found.

It had been thought that such stars would effectively sterilise any planet within their habitable zone – the orbital region around a star where liquid water can form on a planet's surface – by bombarding them with radiation or blasting away their protective ozone layer.

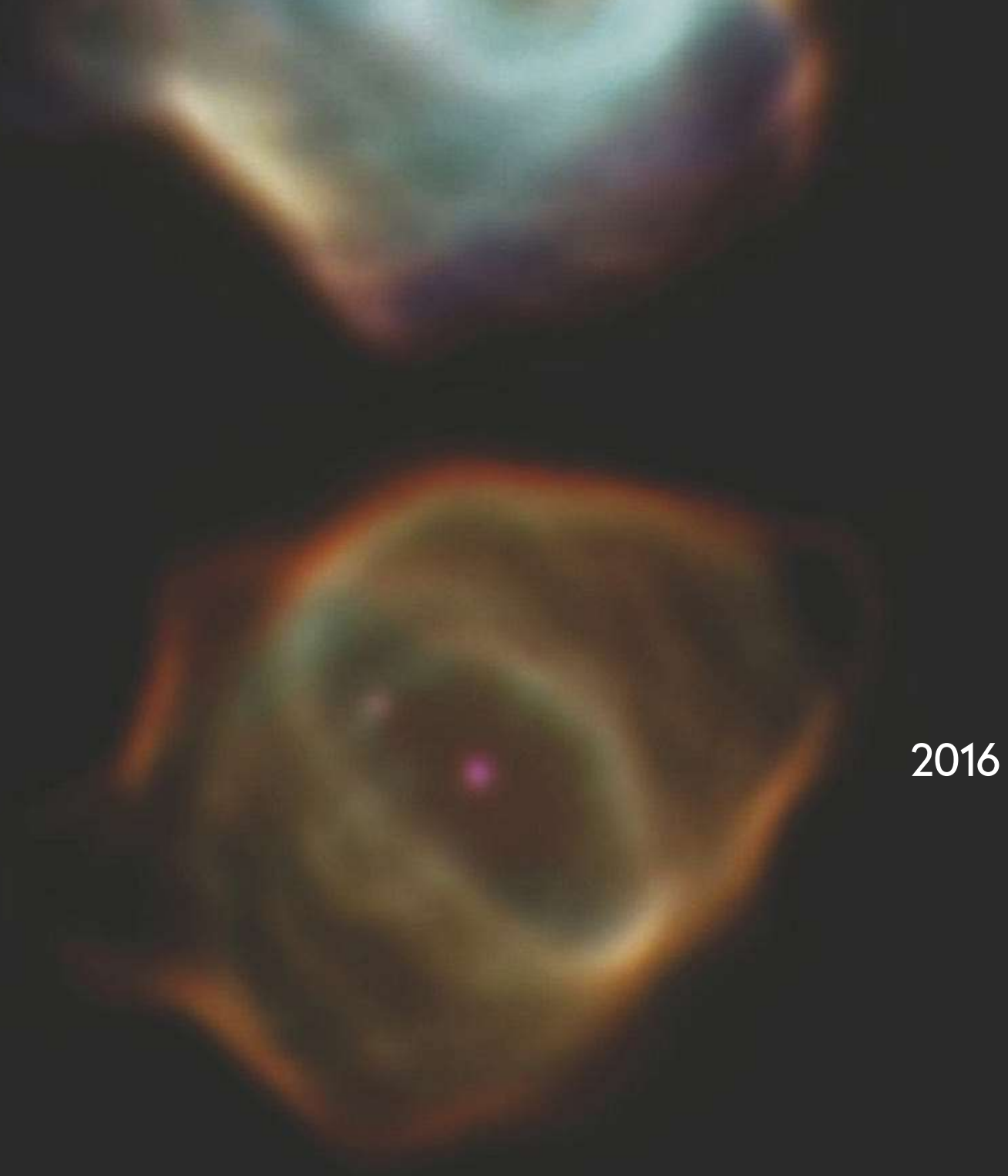
However, a new study which looked into the effect of the flares found they didn't destroy the atmosphere, but drove it to find a different equilibrium that might still support life.

"We've found that solar flares might not preclude the existence of life. In some cases, flaring doesn't erode all the atmospheric ozone. Surface life might still have a fighting chance," says Daniel Horton from Northwestern University (NWU).

If life was able to evolve on these worlds, it would actually be easier to detect as the flares increase the abundance of life-indicating gases such as nitrogen dioxide.


Could solar flares actually help us find life on other worlds?

"Space weather events are typically viewed as a detriment to habitability," says Howard Chen from NWU. "But our study quantitatively shows that some space weather can actually help us detect signatures of important gases that might signify biological processes."
www.northwestern.edu



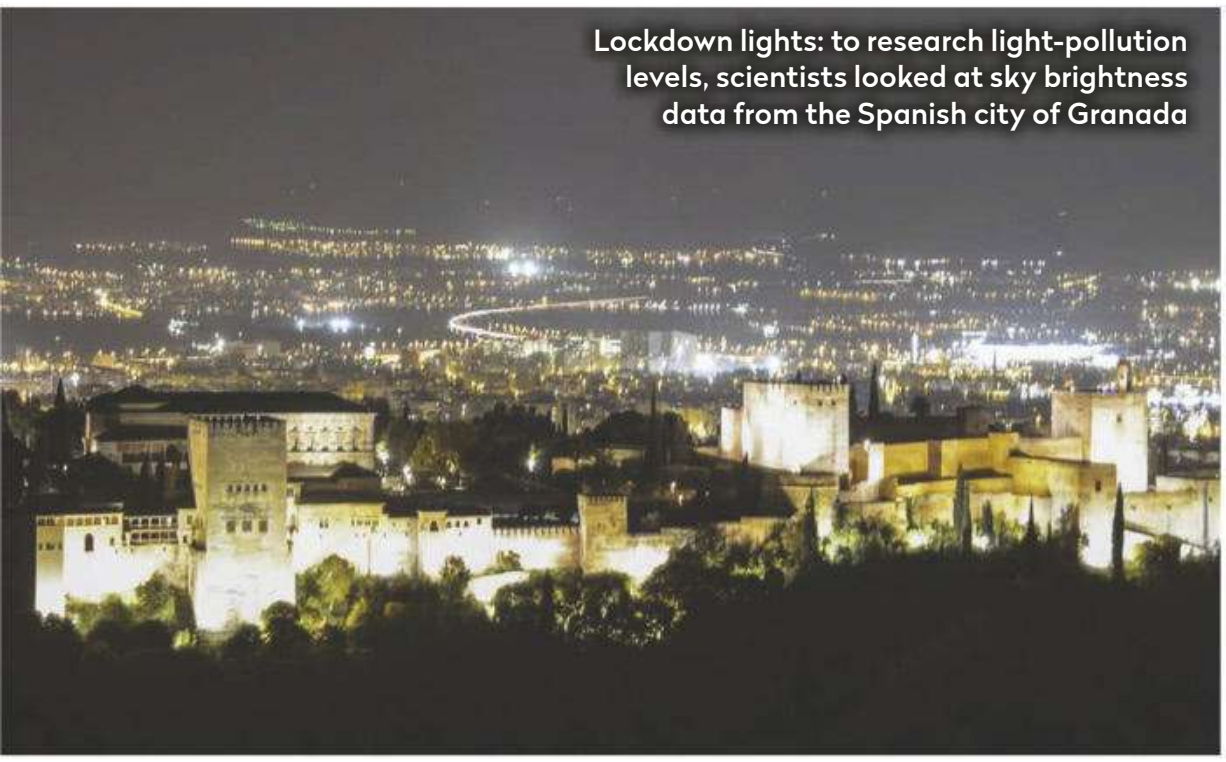
Hubble watches the Stingray fade

For 20 years, the Hubble Space Telescope has watched as the Stingray Nebula faded. These two images of the planetary nebula taken 20 years apart show its dimming. As planetary nebulae are created by a cloud of gas expanding out from a core star, they usually grow in size and brightness, but Stingray's central star is getting cooler and less luminous, making the nebula fainter.

"This is very, very dramatic and very weird," says Martín A Guerrero of the Instituto de Astrofísica de Andalucía in Granada, Spain. "We're witnessing a nebula's evolution in real time. In a span of years, we see variations in the nebula. We have not seen that before with the clarity we get with this view."

Our experts examine the hottest new research

CUTTING EDGE



Lockdown lights: to research light-pollution levels, scientists looked at sky brightness data from the Spanish city of Granada

Has the pandemic helped lockdown light pollution?

With a clear drop in air pollution levels, astronomers were keen to see if restrictions reduced light levels too

One outcome of COVID-19 and the strict national lockdowns during the pandemic is to offer a 'natural experiment' on the relationship between human activity and our effect on the environment. Satellite observations revealed a drop in atmospheric levels of nitrogen dioxide (a major air pollutant released by the burning of fossil fuels) over cities and industrial centres, and levels of 'PM10' sooty particles in the air were also greatly reduced. But what effect are the restrictions on human activity having on light pollution?

The main source of information on global night-time light emissions is the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument aboard the Suomi NPP satellite. But the problem with using this dataset to compare light pollution before and during the pandemic is that the images are taken by the satellite passing overhead at 1:30am local time, long after most people have already gone to sleep and lights are turned off. As Máximo Bustamante-Calabria at the Astrophysical Institute of Andalucía explains, the key to uncovering the effects of human activity is in combining this satellite imagery with local ground measurements of sky brightness. He and his team have collected this data for the city of Granada in Spain, including both before the pandemic and during the lockdown from mid-March to the end of May 2020.

Gathering results

As many amateur astronomers know, the problem of light pollution on the night skies is not just the amount of artificial lighting, but also the haze of PM10 particles in air pollution reflecting that glow back towards the ground. So Bustamante-Calabria and his team had to first disentangle the relationship between the lower levels of particle pollution in the air scattering light, and any decrease in the amount of artificial lighting during the pandemic. When they allowed for these variations, the data revealed that during lockdown the overall light output of the city had decreased by around 20 per cent.

The drop is even more pronounced in the blue end of the light spectrum, where the team measured a 45 per cent decrease in sky brightness during the lockdown. This is due to the reduction in vehicle headlights and private lighting, as well as the ornamental illumination of city monuments. Nowadays, these are usually metal halide or LED lamps that produce a blue-white light, rather than the yellowy colour of sodium lamps. Most of these lights are turned-off by the early hours, however, and so are missed by the satellite imagery – the aforementioned VIIRS data doesn't record any significant difference in the light emission of cities before and during lockdown.

> ***"The key to uncovering the effects of human activity is in combining satellite imagery with ground measurements of sky brightness"***

Given that outdoor activity decreased by up to 90 per cent during lockdown, Bustamante-Calabria concludes that the late-night emissions of the city are dominated by permanent lighting that doesn't respond to the actual behaviour of its citizens. This, he argues, is a clear waste of energy and resources, as well as being a source of frustration for many amateur astronomers.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Effects of the COVID-19 lockdown on urban light emissions: ground and satellite comparison* by Máximo Bustamante-Calabria. **Read it online at: https://arxiv.org/abs/2011.09252**

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Spying on spiralling stars with Gaia

Astronomers are gifted with rich pickings as the European satellite releases another tranche of data

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Has there been a mission with an impact across astronomy to match that of Gaia? I'm not sure. The European Space Agency's satellite is mapping our galactic neighbourhood, recording the positions and movements of more than a billion stars, and astronomers have been waiting for the latest tranche of data for a while. We marked the last major data release in May 2018 with a special episode of *The Sky at Night*, and since then literally thousands of published papers have made use of its measurements to explore the history of the Milky Way, stellar evolution and more.

This month's paper is one of the handful released by the Gaia team themselves to accompany their latest gift to astronomical understanding, what's known as Early Data Release 3. The full DR3 is due in a couple of years, but for now we have positions for 1.8 billion stars – up by 100 million from last time – along with colours for 1.5 billion (up by 200 million) all served with much improved accuracy and precision.

To show what these careful measurements can get you, the team in this month's paper pull out from the Gaia treasury a grand total of 12,884,734 stars that belong to the Large and Small Magellanic Clouds (LMC and SMC), the two largest satellite galaxies of the Milky Way. One of the great joys of the Gaia data is that as well as measuring the position and brightness of stars on the sky, we get measurements of how stars are moving – what's called their proper motion.

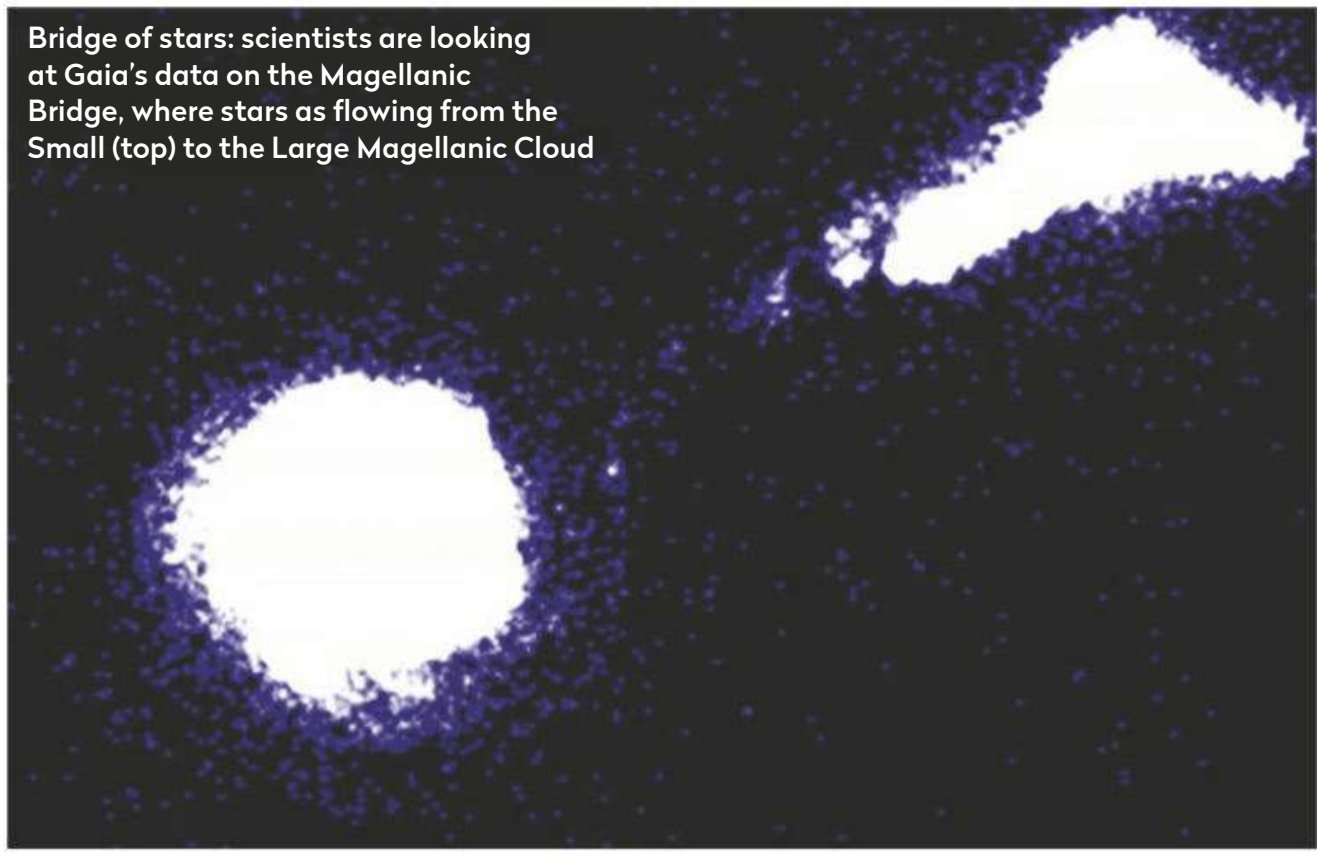
This means we can see how stars spiral in the disk of the LMC, and how they are affected by the more freeform structure of its smaller counterpart. The detail is simply exquisite – we can see how the LMC's stellar bar seems to slow down young and old stellar populations alike and pick out its spiral arms – and it isn't limited to the galaxies themselves. As the two galaxies have orbited and interacted with the Milky Way, they have affected each other. The result is a stream of stars between the two known as the Magellanic Bridge.

New views

Stars in the Bridge have been identified before, but never with such precision or in such abundance. Gaia sees nearly two million stars belonging to the structure, many of which are flowing from the SMC to the LMC. The structure wraps itself around the LMC and seems to feed into the more southerly of the galaxy's arms. This might not be a 'true' spiral arm but rather a feature produced by the interaction between the two systems.

> ***"Stars in the Magellanic Bridge have been identified before, but never with such precision or in such abundance"***

Understanding how galaxies interact and merge is important in trying to piece together the history of the Universe. Applying the kind of techniques the team can use here on the LMC and SMC to populations in the Milky Way, picking out the stars that seem to have come from past events in our own Galaxy's history, will allow us to understand our Galaxy's story better than ever before. Expect Gaia's impact to continue to grow in the years ahead – the mission is a real triumph for ESA and its team of data hungry scientists.



Bridge of stars: scientists are looking at Gaia's data on the Magellanic Bridge, where stars as flowing from the Small (top) to the Large Magellanic Cloud

Chris Lintott was reading... *Gaia Early Data Release 3: Structure and properties of the Magellanic Clouds* by the Gaia Collaboration.
Read it online at: https://arxiv.org/abs/2012.01771

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

In the January episode, PhD student **Naomi Rowe-Gurney** looked back at an eventful year. She reflects on the issues 2020 has raised

▲ Inspirational: "I was blown away when I first saw Maggie hosting *The Sky at Night*. She's been an inspiration for me"

BBC X 2, NASA/JPL/STSCI

Everyone's lives have changed this year. I've been working from home constantly since March and it feels never-ending. As a PhD student in planetary science at the University of Leicester, I'm lucky I can do my research remotely, but I've struggled to adapt to this new lifestyle. What feels like an unhealthy amount of time is spent on Zoom, with too many hours at my computer. I miss those chats with colleagues at tea breaks, in the corridors, and especially in the pub.

I'm in my final PhD year, studying the atmospheres of the ice giants, Uranus and Neptune. I use data from the decommissioned Spitzer Space Telescope to observe how the atmosphere of each planet changes as it rotates. We've only visited each ice giant once, with Voyager 2 flybys in the late 1980s, making them the least explored planets of our Solar System. Strangely, my goal isn't to answer the many outstanding questions about them, but to reveal new ones for the future. This is for the new James Webb Space Telescope, which will launch in October 2021 and will help to give the most detailed insights into their atmospheres that we've ever had. The ice giants are the future of Solar System science and hundreds of scientists across the world are already proposing missions.

Return to a 'different' world

The Sky at Night has been a welcome distraction from the monotony of isolation. The episode with Maggie Aderin-Pocock interviewing astronaut Jessica Meir after she returned from the International Space Station (originally braodcast on 18 June), stands out. Jessica went to space when the world was 'normal' and came home to a completely different planet. She also talked about participating in the first ever all-female spacewalk, and I remember

Naomi Rowe-Gurney is a planetary science PhD student at the University of Leicester

thinking, "Wow, was this really the first?!". We tend to think that women's representation in science is much further along than it actually is. It's true that women are becoming better represented in science, but this fight is only just beginning for other minorities.

I got the 'space bug' at a young age when I visited a planetarium but didn't see myself in the position I'm in now. That's why representation is so important. It's great to have so many women to look up to – but you don't often see Black women. I was blown away when I first saw Maggie hosting *The Sky at Night*. She's an inspiration for me, and I'm sure she is for other Black women and girls pursuing careers in astronomy.

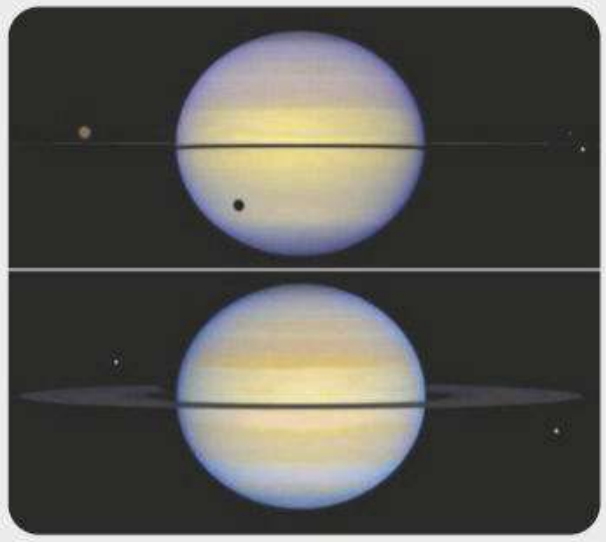
The pandemic has been difficult for so many people. The Black community has been hit especially hard during this time and the fight for equality is at the forefront of many people's minds. At least it's raising awareness of what's been going on for decades. In academia I've seen things starting to happen behind the scenes that will hopefully make life better for future minority students and attract more of them into postgraduate education.

I really enjoyed being on *The Sky at Night*. It was great to get to talk about some of the things that are really important to me, as a Black woman in science. People say "the sky's the limit..." but really it isn't.

Looking back: The Sky at Night

7 February 1980

On the 7 February 1980 episode of *The Sky at Night*, Patrick Moore was joined by Saturn enthusiast and artist Paul Doherty, who often produced artwork for the show. The pair were taking a look at the ringed planet – or rather, the un-ringed planet, as Saturn's most famous feature had been reduced to little more than a slender line of shadow across the planet's face.



▲ **Every 15 years, Earth and Saturn's orbits line up, so its rings are seen edge-on (top)**

Their disappearance of the rings was caused by the fact that they don't stay at the same angle relative to Earth all the time. Instead, they appear to tip up and down as the inclined orbits of the two planets tilt away from each other.

Approximately every 15 years, the orbits line up so that we here on Earth look at the rings exactly edge-on, as happened in 1980. Although the gas giant's icy rings are 400,000km-wide, they are less than 1km thick, and so when viewed edge-on all we can really see is the shadow they cast onto Saturn itself.

You'll have to wait until March 2025 for the next opportunity to capture the spectacle for yourself. Then seven years later, in May 2032, you'll be able to see Saturn's rings when they appear at their most open, as the planet's southern hemisphere will be at its most tipped towards Earth.

The Sky at Night is taking a well-earned break this month and is due to return later in the year, but there is still plenty to see on the programme's official website. Catch up on recent instalments or delve into the archives for some classic episodes, including Patrick Moore's chat with astronomer Clyde Tombaugh who discovered Pluto, coverage of the Voyager, Mariner and Pioneer missions and a report on the Soviet crewed lunar programme first broadcast in 1960.

▲ **Patrick Moore visits Arizona's Lowell Observatory to examine the telescope through which Pluto was discovered in 1930**

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

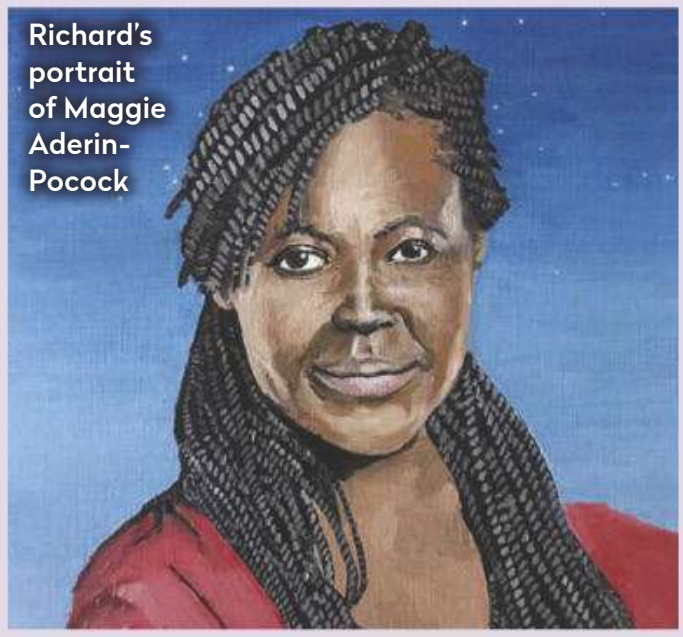
Email us at **inbox@skyatnightmagazine.com**

This month's top prize:
four Philip's titles

PHILIP'S The 'Message of the Month' writer will receive a bundle of four top titles courtesy of astronomy publisher Philip's: Ian Ridpath and Wil Tirion's *Star Chart*, Robin Scagell's *Guide to the Northern Constellations*, Heather Couper and Nigel Henbest's *2021 Stargazing,* and a planisphere for the night skies as they appear at latitude 51.5° north.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH



Richard's portrait of Maggie Aderin-Pocock

Artistic tribute

I have only recently taken up painting again after I left school 40 years ago. Portraits have always interested me, but I haven't had the courage to attempt them... until now. But who to choose?

Science, and especially astronomy, have always been a keen interest of mine and so I wanted to pick someone who I thought communicated complex ideas in an engaging and accessible way to novices like me. As a former teacher I appreciate the importance of doing this and as *The Sky at Night* has been a favourite of mine for years, I chose presenter Maggie Aderin-Pocock. Her personality, passion, expertise and ability to engage an audience made this a natural choice. I wanted to achieve a painting that showed her authority and intellect, combined with friendliness and approachability. Hopefully, I have captured that and it does justice to a scientist that is inspirational to me and many others.
Richard Bleasdale, Birmingham

A wonderful likeness, Richard, congratulations on a fine portrait!. ***– Ed.***

Tweet

Susan Pilcher
@susanpilcher1 • Dec 12
One Geminid over Dungeness. 3 hours for this! #Geminid #geminids #Meteorshower #dungeness #romneymarsh @VirtualAstro @VanguardPhotoUK @skyatnightmag

Online star

Brother Guy Conslomagno's Christmas Lecture, 'The Great Conjunction and The Star of Bethlehem', was my very first *Sky at Night Magazine* webinar and I look forward to many more. The time allotted seemed perfect for the topic and the amount of time I could put aside for it.

I enjoyed both the subject matter and Brother Guy's presentation of it. I learned a lot, but the way he presented some of the material, and answered people's questions, had me looking at things in a different way than I had previously, which was really amazing. So, thank you for having the webinar, I got a lot out of it!
Bethany Ford, via email

Narnia's night sky

I enjoyed the feature on conjunctions of planets in literature through history ('The Great Conjunction: history in the making', December 2020 issue). Although perhaps not considered great literature, I was reminded of the scene in *Prince Caspian* (1951) by CS Lewis, where the young prince is woken one night by Doctor Cornelius and taken up to the castle battlements to see a conjunction. In the world of the Narnia books there are many references to its special astronomy. In this conjunction, "Tarva, the Lord of Victory, salutes Alambil, the Lady of Peace". On the evening of 21 December I was looking out for the conjunction between Jupiter and Saturn, but part of me was in Narnia.
Mark Hurn, Institute of Astronomy, University of Cambridge

Double impact

I expect there are hundreds of images of the recent conjunction between Jupiter

A Christmas setting: Roger's photo of the Great Conjunction

and Saturn. However, here is one with a Christmas slant (above), taken from my garden in Nailstone (near Nuneaton) with a Sony DSC-HX60 compact camera, and the parish church also in view. **Roger Samworth, Nailstone** ▸

ON FACEBOOK

WE ASKED: NASA has selected you for the first trip to Mars. Do you go?

Scott Wigglesworth For all humankind. A new frontier. The realisation of the dream of generations and a chance to be part of the foundation of a future in which humanity thrives out there among the stars? Measure me up for a flight suit!

Wayne Ryles Well a change of scenery would be nice after being stuck in lockdown for most of the year.

Andrew Ball Knowing my luck I'd get dropped off on the wrong planet.

Stuart Brennan Can you promise what happened to Matt Damon won't happen to me?

Mark Whalebone I would say, "What took you so long?" I have been waiting to go to Mars since I was a young child watching the Moon landings!

Jerome Watson Mars, a world without politicians and lawyers, at least in the beginning. It won't be long before they turn up and spoil it, but it will be paradise till then. I'd go in a heartbeat!

Mark Lee The trip would be unnecessary and far too dangerous. Send a robot.

Tony Moss At 68 years old I might explain that I would be more of a hindrance than a help, but thanks anyway.

Colin Anderson Yes, I'd definitely go, even if it were a one way trip. We dreamed of such things as kids and, although I know intellectually it will never happen, that dream is still alive. Just to go into space would be awesome; to stand on another planet...

Paul Parsons I've always been averse to space travel, purely because I don't enjoy travel and in the extreme it makes me physically ill. But right now, I've never felt such an urge to leave this country and indeed leave this planet.

Malcolm Dixon I've already packed. My passport only has five years left before renewal, so there may be a bit of an issue getting back!

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I have a Sky-Watcher 200PDS Newtonian and use a 2x Barlow and Canon 650D DSLR camera to take planetary images, but Jupiter often looks like no more than a dot and I can't focus my eyepieces when using the Barlow lens. Can you help?

RICHARD WHITE

◂ Planets can appear small when imaged with a Sky-Watcher 200PDS

The Sky-Watcher 200PDS Newtonian reflector has a focal length of 1,000mm. However, its tube length has been reduced and the secondary mirror moved closer to the primary mirror. This design results in the focal plane extending further outside the focuser to give more back-focus, specifically for astrophotography. The use of a Barlow lens further increases the apparent back-focus, making camera focus easy to achieve.

In your case, I suspect that there isn't now sufficient outwards focus travel to achieve focus with your eyepiece and Barlow lens combination. The solution is to add an extension tube between the Barlow lens and the focuser's eyepiece holder.

Photographing the planets with a relatively short focal length instrument like your 200PDS will always result in a small image and this will be exaggerated by the large sensor of your DSLR camera as you need to zoom in on the finished image to see it. For planetary imaging rather than observing, you would be better off with a longer focal length telescope.

Steve's top tip

What are flat fields?

The lenses and mirrors in a telescope have curved surfaces, which results in a curved focal plane, so stars at the centre of the field of view can be very well focused, while those towards the periphery are slightly de-focused and elongated. For visual observing purposes, this is not particularly noticeable except under close scrutiny, but it becomes very apparent when imaging because the camera's sensor is flat. Imagers aim to correct this issue using field flatteners, which are special optical accessories that re-focus the light across the whole field of view accurately on the sensor, thus producing a 'flat field'.

Steve Richards is a keen astro imager and an astronomy equipment expert

WWW.ROTHERVALLEYOPTICS.CO.UK

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Changing opinion

▸ I always thought of Dobsonian mounts as cheap and nasty, but when I decided to upgrade from a 127mm Maksutov scope and saw that I could get a Sky-Watcher Skyliner 200P (200mm) Dobsonian reflector for the same amount that I paid for the Maksutov 12 years ago – and it was highly commended in a *Sky at Night Magazine* review – I went for it.

The telescope is awesome and the Dobsonian mount is the sturdiest, most stable and easiest to move of any that I've used. There's no more wrestling with three unwieldy legs or huge heavy pillars, the eyepieces are always in a comfortable position and the views are brilliant!

Videos on YouTube say Dobsonians are ideal beginner's scopes. As I've been interested in astronomy and owned telescopes of various types for over 50 years, I don't class myself as a beginner; this kind of scope is perfect for any level.
Graham Easby, via email

CORRECTIONS

• The picture on page 33 of the December 2020 issue's article 'The Great Conjunction: history in the making', was captioned as showing a Gregorian telescope when it showed a Newtonian telescope.
• On page 76 of the same issue, in 'Astrophotography Capture: Photograph the Great Conjunction', the formula to calculate the field of view (FOV) for imaging the conjunction should have read, FOV in arcminutes = imaging chip width in mm x 3,438 ÷ telescope focal length in mm, where 3,438 replaces the incorrect 3,460.

SOCIETY IN FOCUS

Swansea Astronomical Society, like many other organisations, has had to adapt quickly to an ever-changing situation; our main concern at the beginning of the COVID-19 outbreak was to keep the society together so we would not see a drop in our membership, especially among those classed as elderly and vulnerable.

Out went our regular meetings, which are held at a local university, meaning we were unable to meet anyway as the building is closed to all except a few students. Our observatory is also out of use as we cannot socially distance.

All our talks are now held over Zoom; an advantage is that we have been allowed by some speakers to make recorded sessions available for those who are unable to watch live. We've also managed to sign up speakers who live further away and this is something we may continue with once restrictions are lifted, with a mix of both live and Zoom talks to widen our speaker base.

▲ Members of Swansea Astronomical Society meet regularly on Zoom

When it comes to observing, some of our members have been experimenting with remote observing using their own home-based equipment. This has worked well and we've featured the results in our warm-up preamble news before our Zoom talks. We hope that we can use this setup and broadcast from our observatory in future, especially during meteor showers and other events.
Phillip John, vice-chair, Swansea Astronomical Society
▸ www.swanastro.org.uk

COVID-19
Online and socially distanced events taking place this month

We pick the best live and virtual astronomy events and resources this month

WHAT'S ONLINE

StarFest Dark Skies Festival
Cranborne Chase, 15–20 February
The International Dark Sky Reserve hosts a mix of online and (subject to restrictions at the time) live events, including talks on astronomy basics, astrophotography, storytelling and activities for kids. See the full schedule at **www.chasingstars.org.uk**.

DOCUMENTARY
Behind the Curve
The Earth isn't rotating and 'Earthrise' was faked. Or so believe the fact-phobic subjects of this highly entertaining documentary exploring modern-day Flat Earthers, the startlingly large number of people who put our globe into the category of 'fake news'.
www.netflix.com

ONLINE TALKS
Newtown Astronomy Society
13 February
Newtown Astronomy Society (NAS) has a great programme of Zoom talks planned for the coming months, including Rob Davies on home observatories on 13 February and Pete Williamson's talk, 'From Birr to Hubble' on 13 March. Free to members; £2 for guests (contact **secretary.newtownastrosoc@gmail.com** in advance to register).

Solar webinar
20 February
Catch the British Astronomical Association's (BAA) livestream of its Solar Section webinar. There will be three presentations, plus Q&As.
bit.ly/3gvnrhB

PICK OF THE MONTH

▲ Under Yorkshire skies: enjoy stargazing activities around the theme of 'Nature at Night'

Yorkshire's Dark Skies Festival 2021
Various venues, 12–28 February

The North York Moors and Yorkshire Dales festival returns, hot on the heels of the two National Parks' designation as International Dark Sky Reserves, with the theme of 'Nature at Night'. Expect a range of events across the moors, dales and coastline, focusing on all things natural and nocturnal, with an emphasis on the damage light pollution does to our wildlife.

Planned are stargazing safaris with expert astronomers as guides, fun treasure hunts, ghost walks, dark-sky trail runs and cycle rides. There's also the chance for private stargazing evenings if you opt to stay at one of the dark-sky-friendly accommodation options.

All events will have COVID-19 safety measures in place and most need to be pre-booked. For more information, visit **www.darkskiesnationalparks.org.uk**

Strange Signals: Fast Radio Bursts
28 February, 7pm
Bursts of energy that last milliseconds, travel across galaxies and arrive from anywhere in the sky. What are they and where do they come from? Join an astronomical detective hunt for Fast Radio Bursts. Details at **bit.ly/39Uidus**.

ONLINE COURSE
Moons
Starts 15 February
Join Moon master Professor David Rothery for a free 8-week Open University course exploring the many moons of our Solar System. Book a place at **www.futurelearn.com/courses/moons**.

PODCAST
NASA's Curious Universe
NASA astronauts, scientists and engineers tackle a fascinating new subject each week, like Crawlers (the gargantuan caterpillar-tracked vehicles that carry rockets to the launchpad) or the hotly anticipated James Webb Space Telescope. **go.nasa.gov/2K9r5RX**

YORKSHIRE'S DARK SKIES FESTIVAL, STARFEST DARK SKIES FESTIVAL

NEW

TRIUS PRO

BLUE Series

Introducing the New Starlight Xpress
TRIUS PRO BLUE Series cooled CCD cameras

The new **TRIUS PRO** BLUE Series follows on from the incredibly successful TRIUS PRO cameras. It offers the same amazingly quiet drive electronics which gives the lowest read-noise figures and fastest downloads in its class, and now in this new stunning, metallic blue colour.

We have read-noise figures that are better than most CMOS cameras*, along with 16bit data, large full well depths (large dynamic range), and significantly lower dark-noise figure thanks to the impressive compact cooling system; these really are the best deep-sky imaging cameras on the market. With the **TRIUS PRO** BLUE Series cameras, dark frames really are a thing of the past, making calibration frames optional rather than compulsory, giving you more time to capture fantastic data that requires less processing.

Our helpful and friendly staff are on hand to help you choose the best camera for your setup. Don't forget our New MIDI filter wheel with built-in OAG and Lodestar X2 autoguider to complete your imaging system. Visit our website for further information. www.sxccd.com

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- **High QE**
- **Ultra-low dark current**
- **Argon filled CCD chamber**
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- **Faster download speed**
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Manufactured in United Kingdom

2.8M Pixel

6.1M Pixel

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FIELD OF VIEW

Five predictions for 2021 in space

Her Excellency Sarah Al Amiri, Chair of the UAE Space Agency, highlights the main influences on spaceflight this year, from Mars missions to sustainability

Her Excellency Sarah Al Amiri is the Minister of State for Advanced Technology and Chair of the UAE Space Agency

We're going to Mars

One prediction I can most assuredly make is that the Emirates Mars Mission will reach Mars orbit insertion on 9 February 2021. By April we'll have pivoted from our 'capture orbit' to our 'science orbit' and by September we'll be sharing our data stream with scientists and researchers around the world. For the coming Martian year (about two Earth years), we'll be analysing the atmospheric dynamics of Mars. We've got our fingers crossed for a planetary dust storm because the Hope probe is equipped to measure what stands as one of Mars's most enigmatic phenomena.

Space is open for all – and it will open more

The Emirates signed the Artemis Accords (an international agreement of governments participating in space exploration) in 2020 and we fully expect many more nations to accede to the protocols in 2021 – a further clarification of the open standards, interoperability and teamwork in space systems research and space exploration. As a key international partner and collaborator, we believe passionately in any move that helps the international community to better work together on a level and cooperative playing field.

The role of governments will change

More and more private sector players are joining in space exploration and their participation is changing the landscape, as more nimble operators are exploring faster innovation methods. Instead of spending 10 to 15 years developing huge and complex platforms, innovators are deploying CubeSats and small-scale satellites. The vitally important role of SpaceX, for instance, in NASA's human spaceflight programme shows clearly that private sector players are not only here to stay, but are displacing more traditional models of space exploration.

Missions on a laptop are the new norm

Last year showed us that we can move away from outdated ideas of a physical 'workplace', with COVID-19 accelerating the modernising move to remote working. The Emirates Mars Mission was completed by a multinational team all working from home, conducting calls over Zoom.

The images many of us hold in our minds of hundreds of workstations around giant 100-metre screens are a thing of the past. The Emirates Mars Mission's control facility is a cluster of small rooms with desks, laptops and screens. This is a clear sign of the increased agility that is transforming the sector.

Sustainable space exploration

We have a greater understanding than ever before of our planet, provided by the new data sets we have access to. Ironically, as it becomes easier to launch smaller satellites for planetary exploration, the potential proliferation of space debris and harm to the precious space environment increases. We must not neglect our responsibilities to protect Earth's atmosphere in the process – the tiny layer of atmosphere surrounding our planet is the only breathable atmosphere we have observed that is available to humanity.

In 2021 we will look for more innovative solutions to address space junk, such as by using a 'vacuum-cleaner' method, without prohibiting the development of the space industry or restricting access to space by imposing design restrictions on current spacecraft.

RICARDO BESSA/FOLIO

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BBC Sky at Night MAGAZINE

Standing guard: the beautiful constellation of Orion, the Hunter graces the night sky early in 2021

A guide to stargazing in 2021

It's set to be a great year for observing the night sky. **Jamie Carter** reveals what to look for in the next 12 months

The stars may be enduring, but our sky is always changing thanks to the orbits of the planets and our Moon. So what can stargazers expect in 2021? "We won't have a spectacular Mars in 2021, and nor will we have any particularly close conjunctions, but we will have Venus looking brilliant," says Nigel Henbest, author of *Philip's 2021 Stargazing Month-by-Month Guide to the Night Sky in Britain & Ireland*. "There is always a lot of interest in conjunctions, but what people really love is a crescent Moon with a planet. Crescent Moons tend to be quite low down on the horizon, too, so they're easily noticed."

There is also arguably the UK's biggest celestial event of the year. "The solar eclipse on 10 June will be seen as an annular 'ring of fire' from Northern Canada, but as a large partial eclipse from across Europe," says Henbest. "It will be the biggest solar eclipse visible from the UK for six years."

A mix of conjunctions, planetary oppositions, eclipses and perennial favourites – many of which can be observed with the naked eye – here are 21 of the best sights for 2021...

1. The Orion Nebula at its best

When: December–February
Where: highest around midnight

Orion's Belt is one of the night sky's most easily found and best-loved sights of winter, but there's something astonishing lurking just beneath it. The Orion Nebula, also known as M42, is a diffuse cloud of gas and dust about 1,300 lightyears distant where stars are being born in the Milky Way. One of the brightest nebulae of all and easily visible to the naked eye, M42 is hugely rewarding in binoculars and a small telescope. Look slightly to the side of it to appreciate its brightness with your more sensitive peripheral vision.

2. Mars close to the Pleiades

When: after dark on 3 March
Where: southwestern night sky

Remember the spectacular sight of bright planet Venus within the Pleiades open cluster in April last year? It's happening again, this time with the Red Planet, which will be close to the Pleiades – also known as the Seven Sisters – for a few nights either side of its closest pass on 3 March.

3. Mercury and Jupiter in conjunction

When: just before sunrise on 5 March
Where: low on the southeastern horizon

Search the eastern pre-dawn sky and you'll find tiny Mercury, now at its maximum separation from the Sun, just 17 arcminutes above gas giant Jupiter. This conjunction between the Solar System's smallest and largest planets will occur in the constellation of Capricornus, the Sea Goat. You'll likely need binoculars, but be very careful using them close to sunrise. Mercury takes just 88 Earth-days to orbit the Sun, while Jupiter takes 11.87 Earth-years.

4. Moon and Mars in conjunction

When: after dark on 19 March
Where: southwestern night sky

Having drawn away from the Pleiades, on 19 May Mars will be visited by a 32%-lit crescent Moon. The night before, on 18 March, a 24%-lit Moon will form a loose triangle with Mars and the Pleiades.

5. The Beehive Cluster at its finest

When: around midnight, February to May
Where: high in the southern night sky

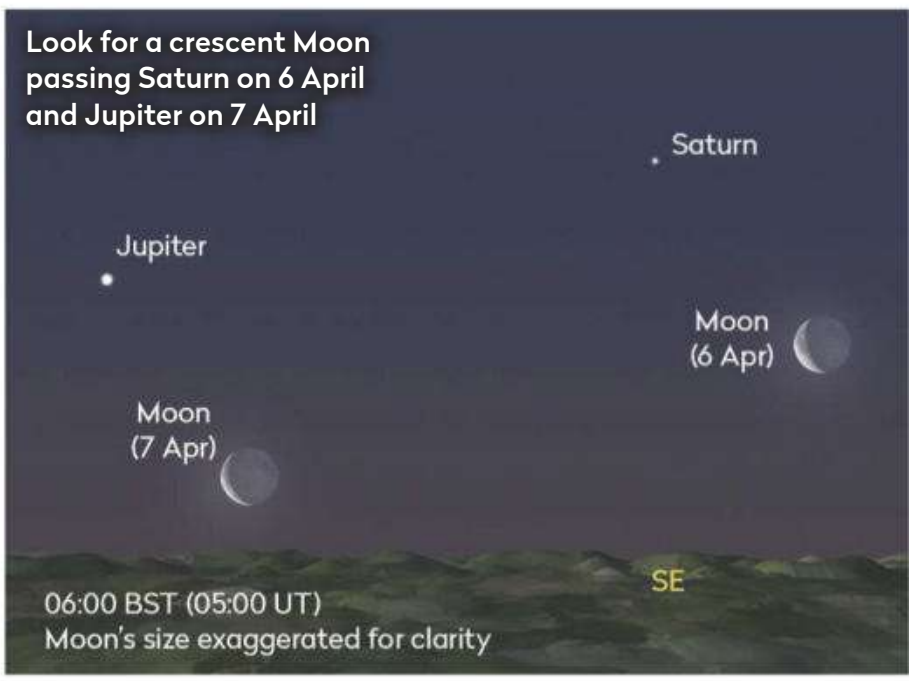
The Beehive Cluster is an open cluster of stars, about 520-lightyears distant, in the constellation of Cancer, the Crab. It is one of the best-looking open clusters of stars and one of the nearest to the Solar System. Also known as both Praesepe and M44, it appears as around 60 stars in a pair of binoculars, though a dozen or so stand out.

6. Crescent Moon, Jupiter and Saturn

When: just before sunrise on 6 and 7 April
Where: southeastern sky

With Jupiter and Saturn having emerged in the pre-dawn skies, you can watch a 31%-lit crescent Moon pass them on successive mornings if you look low to the southeastern horizon (see below). It will pass ▸

ERKKI MAKKONEN


Look for a crescent Moon passing Saturn on 6 April and Jupiter on 7 April
Saturn
Jupiter
Moon (6 Apr)
Moon (7 Apr)
SE
06:00 BST (05:00 UT)
Moon's size exaggerated for clarity

▸ Saturn on 6 April followed by Jupiter on 7 April, with the former taking place in darker skies.

7. The Milky Way's core

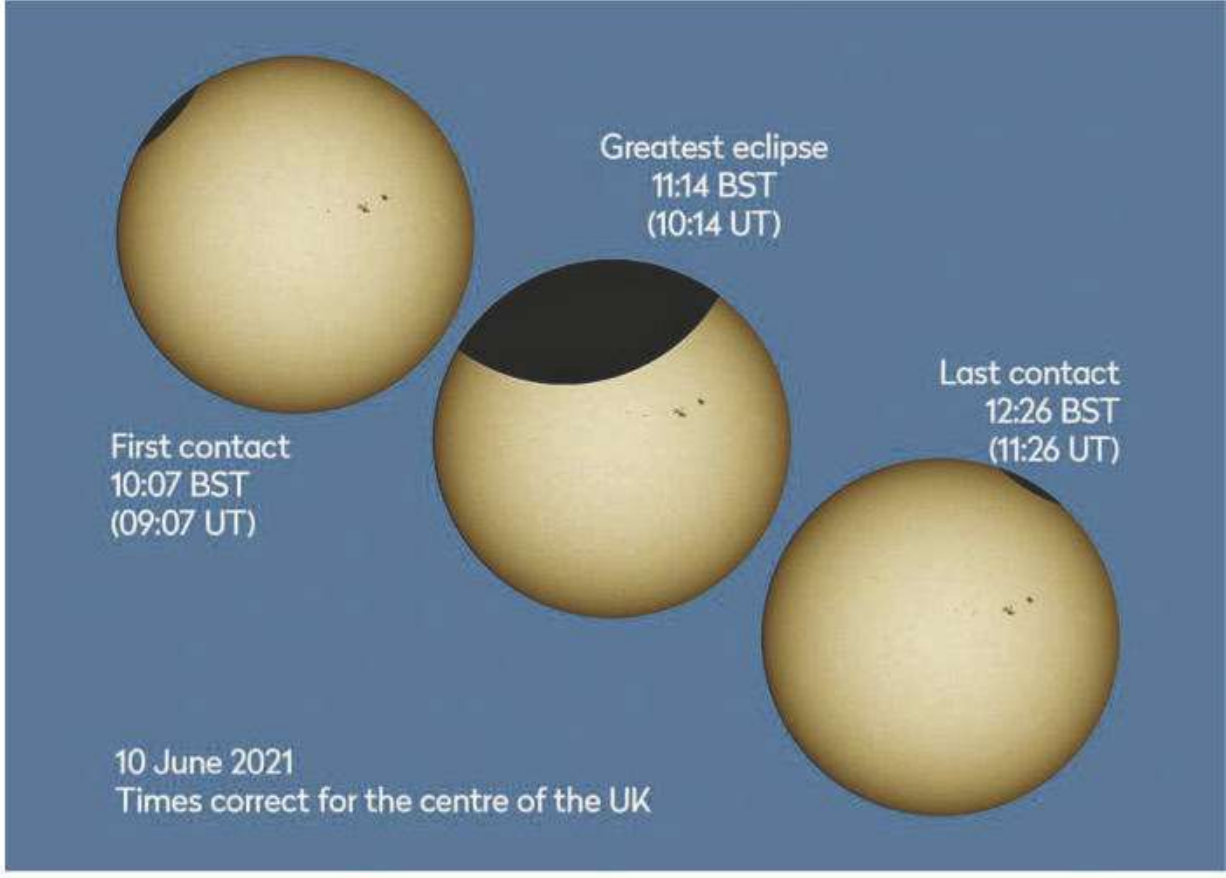
When: April–September
Where: southern night sky

The bright centre of our Milky Way Galaxy lies in the constellations of Sagittarius, the Archer, and Scorpius, the Scorpion, both of which never climb that high in UK skies, so it helps to know when's best to see them. The area emerges from the horizon in April, rising around midnight; by mid-June it rises just after sunset, and by July it's already up after dark. The further south you travel on the planet, the higher Sagittarius and Scorpius are in the night sky, and so the brighter our Galaxy's core. Even a trip to southern Spain or the Canary Islands can make all the difference.

8. A crescent Moon, Venus and Mercury

When: just after sunset on 12 and 13 May
Where: low on the northwest horizon

Are you always among the first to spot the 'young Moon'? A badge of honour among some keen-eyed Moongazers, there's an extra prize for anyone out hunting for a 1%-lit crescent Moon in the post-sunset sky on 12 May, in the form of the planet Venus just 1° above. An easier sight will occur 24 hours later when a 3.5%-lit crescent Moon is visible just next to Mercury, and above Venus. You'll need binoculars to see this.



▲ Rare opportunity; if you observe the partial solar eclipse on 10 June, make sure you take precautions for safe solar observing

9. Venus as an 'Evening Star'

When: after sunset, April–December
Where: western night sky

After spending the latter months of 2020 as a 'Morning Star', Venus will be a fading sight in early 2021, and lost to the Sun's glare by March. Emerging into the post-sunset western skies as an 'Evening Star' in April, Venus will be blazing at mag. –3.9 by May and even brighter in June and July as it gets

IAN DYBALL

When to watch the Moon

Keep an eye on our closest celestial neighbour to spot three 'supermoons', a blue Moon and a faint lunar eclipse

Our natural satellite is in for a busy 2021. It will eclipse the Sun twice and itself be eclipsed twice by Earth. But what's sure to grab the headlines is the annual spate of 'supermoons'.

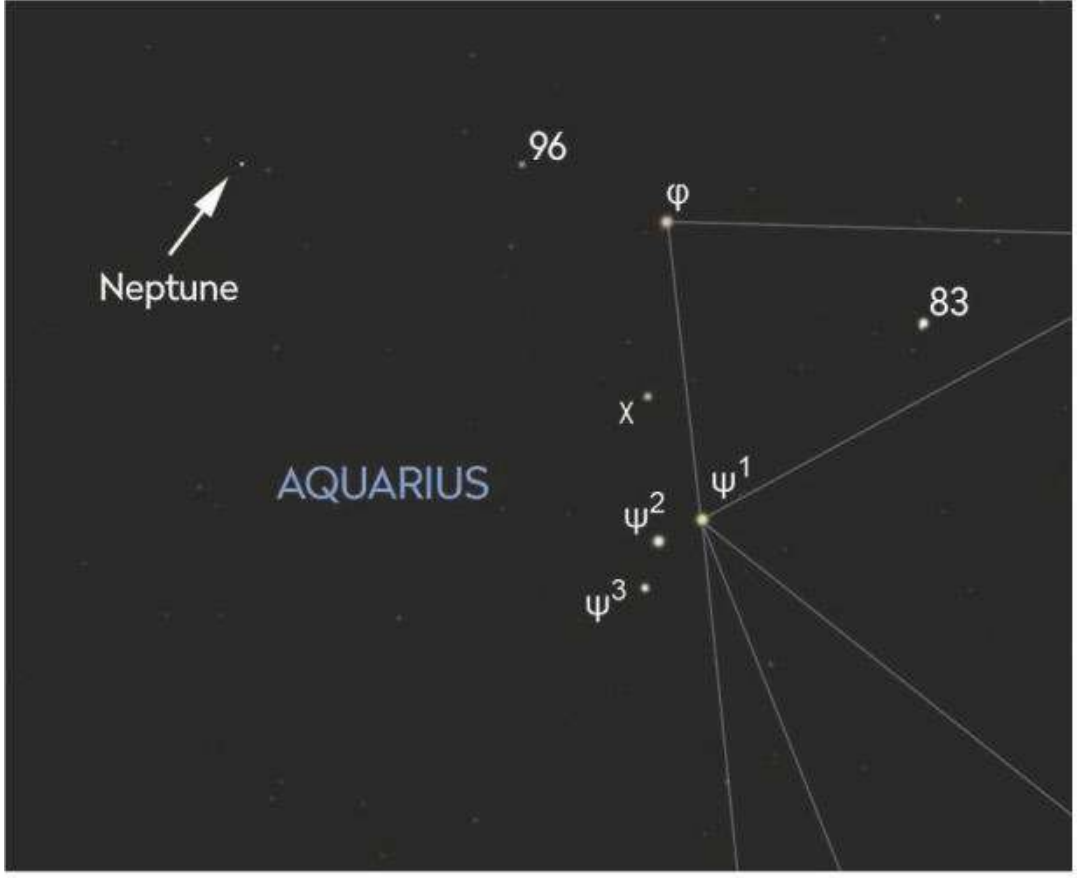
"A supermoon is when the Moon is at its closest to Earth while at full phase," says Nigel Henbest, about what astronomers call a perigee full Moon. They occur because the Moon's monthly orbit of Earth is slightly elliptical. "The technical definition of a supermoon is a full Moon that's within 10 per cent of its closest approach to Earth, which means we can usually declare three supermoons in a year." adds Henbest, who thinks supermoons tend to get beginners interested in astronomy, but don't tend to grab the attention of more experienced astronomers.

In 2021 that definition creates three 'supermoons' on 27 April, 26 May (the closest and therefore biggest perigee full Moon, so the 'best' of 2021) and 24 June, the latter the lowest-hanging full Moon of the year.

"When the Moon is viewed close to the horizon it always looks bigger," says Henbest about the so-called 'Moon illusion'. "An ordinary full Moon close to the horizon will appear larger than a supermoon high up in the night sky." This means it's best to view the full Moon – supermoon or not – as it rises and sets.

Later in 2021 there's a 'seasonal blue Moon', a calendar quirk that sees a full Moon on 22 August become the third of four full Moons in the astronomical season of summer. More interesting still is the full Moon of 19 November, which from the UK will just be visible as a slight penumbral lunar eclipse starting at 06:02 UT, during which our satellite will pass through Earth's outer shadow just before moonset in the west-northwestern sky. From North America, the Pacific and East Asia it will be a partial lunar eclipse during which some of the lunar surface may redden slightly.

▲ Look for a penumbral lunar eclipse on 19 November, beginning at 06:02 UT



▲ Be prepared: a Go-To telescope will help you to locate Neptune at opposition on 14 September

closer to Mars. After a dazzling summer it will sink earlier each month and gradually slim to a crescent by December as Earth and Venus get close.

10. The best solar eclipse since 2015

When: observe from 10:07 BST (09:07 UT), 10 June
Where: 23° above the south-western horizon
A rare partial eclipse of the Sun will be observable from the UK today (see opposite, top), though exactly how much of the Moon covers its disc depends on where you are. In northern Scotland observers will see as much as 32 per cent of the Sun eclipsed, in west Wales 25 per cent and in London 20 per cent. It's actually an annular solar eclipse, with viewers in northern Canada, Greenland and far-east Russia seeing a 'ring of fire' around the Moon for up to 3 minutes 33 seconds.

11. Venus, Mars and a slim crescent Moon

When: just after sunset on 11 and 12 July
Where: just above the western horizon
For those with clear western horizons there's the tempting sight on 11 July of a very bright Venus closely flanked by a dim Mars and a 3.4%-lit crescent Moon. The following evening the Moon will be 8.4%-lit and just above the two planets. However, Venus will appear to be 200 times brighter than Mars.

▲ Saturn will appear at its brightest at dusk on 2 August

12. Saturn at opposition

When: dusk on 2 August
Where: rising in the eastern night sky
A planet is said to be at opposition when Earth is between it and the Sun. That's what happens tonight to Saturn (above), with the 'ringed wonder' being at its brightest and best for all of 2021. Rising at dusk in the east and setting at dawn in the west, a small telescope can be used to glimpse Saturn's rings, and possibly its largest moon Titan.

13. The Summer Triangle at its finest

When: July and August
Where: overhead around midnight
One of the anchors of the summer night sky, the Summer Triangle is something that can never be unseen once you've discovered it. Comprising Deneb (Alpha (α) Cygni), bright Vega (Alpha (α) Lyrae) and Altair (Alpha (α) Aquilae), the Summer Triangle has the Milky Way streaming through it. To the left of a line between Deneb and Altair is the sparkling small constellation of Delphinus, the Dolphin, while just above Altair is tiny Sagitta, the Arrow.

14. Jupiter at opposition

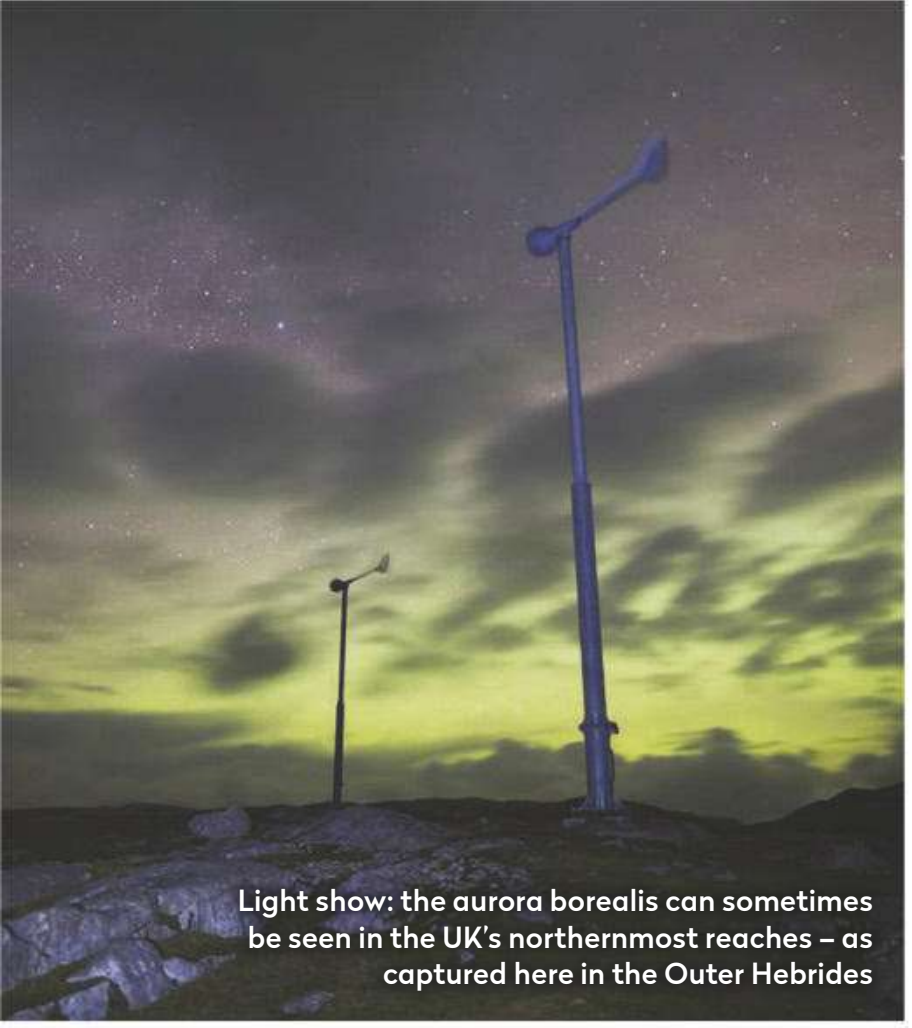
When: dusk on 19 August
Where: rising in the eastern night sky
Every telescope owner's favourite planet will tonight appear to be 100 per cent illuminated as seen from Earth and be observable from dusk until dawn. It's a great week – and in practical terms a great month or two – to point a telescope at the 'King of Planets' and glimpse its browny-orange stripes. But even a pair of binoculars with 7x or 10x magnification will afford you easy views of the gas giant's biggest moons Ganymede, Europa, Callisto and Io.

15. The Andromeda Galaxy at its best

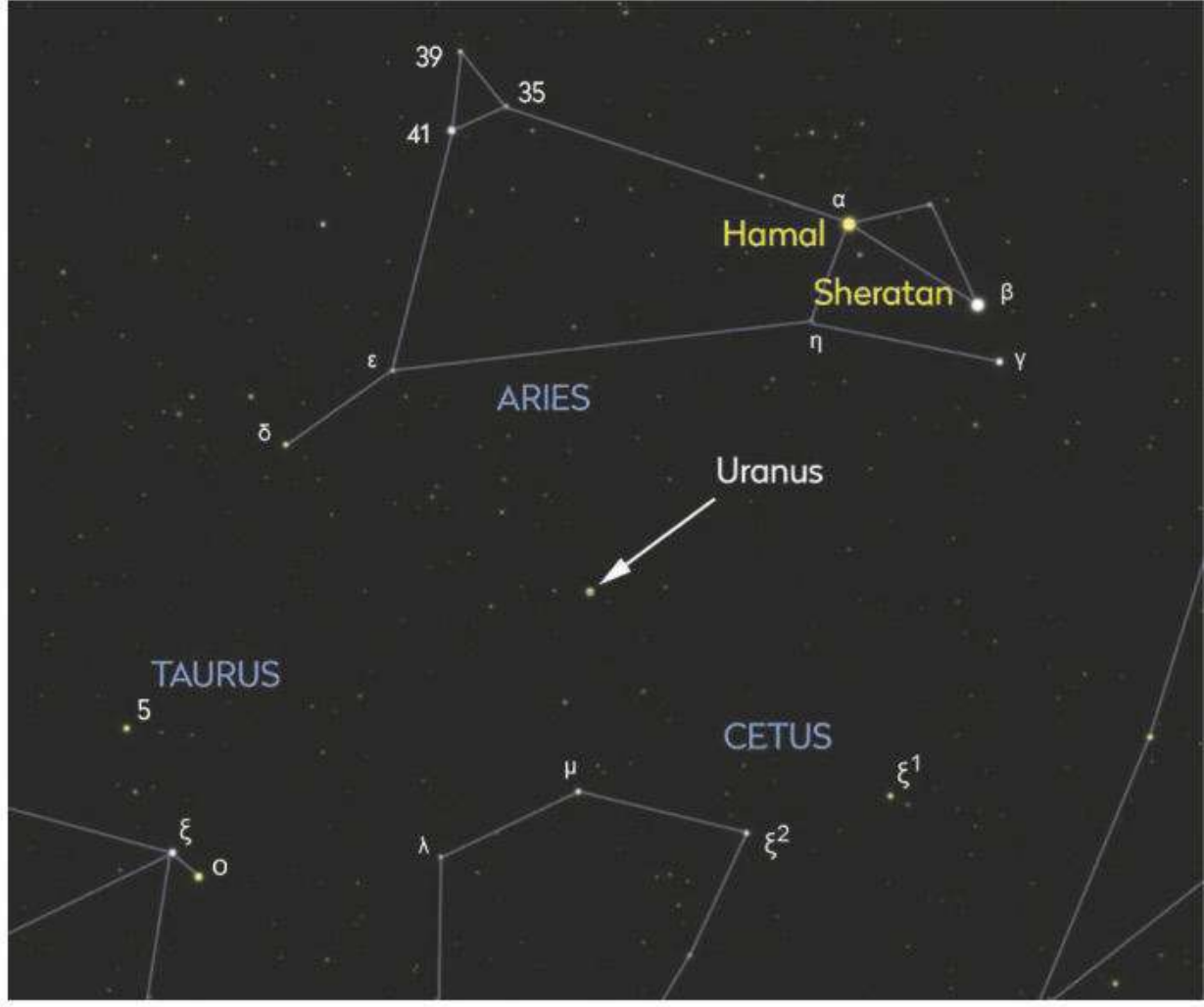
When: around midnight, September and October
Where: overhead
The closest large galaxy to our own Milky Way is also the most distant object you can see with unaided eyes. A spiral galaxy of a trillion stars around 2.5 million lightyears distant, you'll need dark skies to see M31, though it's with a pair of binoculars that you'll get the best sight. It's located roughly halfway between the star Alpheratz (Alpha (α) Andromedae) at the corner of the Great Square of Pegasus, and the star Schedar (Alpha (α) Cassiopeiae) at the point of a 'V' in the 'W' shape of Cassiopeia, the Seated Queen.

16. Neptune at opposition

When: 14 September
Where: rising in the eastern night sky
Though any time this season is a good time to look for Neptune (see top), on 14 September Earth lies between it and the Sun. This 'pale blue dot' can be glimpsed in a pair of binoculars or a small telescope, though only in the latter will you notice any kind of colour. It's just below the Circlet Of Pisces, but you're ►



Light show: the aurora borealis can sometimes be seen in the UK's northernmost reaches – as captured here in the Outer Hebrides



▲ **Catch Uranus at its brightest, at opposition on 5 November**

▸ likely to need a detailed star chart or a Go-To scope because Neptune is tough to find with the naked eye.

17. Northern Lights season

When: January–March, September–December
Where: northern sky

Also known as the aurora borealis, the phenomenon of mostly green lights in the night sky is caused by charged particles from the Sun being accelerated down the field lines of the Earth's magnetic field. Although the best views are from around the Arctic Circle in Iceland or northern Scandinavia, it is sometimes possible to see the aurora borealis from Scotland's far north. Often especially active around the date of September's equinox, strong displays of the Northern Lights ought to be getting more frequent now the Sun has entered a more active part of its 11-year cycle.

18. Uranus at opposition

When: 5 November
Where: rising in the eastern night sky

With the 'sideways planet' at mag. +5.7, don't expect fireworks, but tonight the seventh planet from the Sun reaches its brightest and largest. Opposite the Sun in Earth's sky and rising at sunset, this blue-green

Photo opportunity: the Perseids can be great astro-imaging targets

All-sky delights

Look out for three meteor showers that will be unaffected by moonlight

Beloved of patient stargazers, meteor showers demand clear, dark and moonless skies. Getting away from light pollution is imperative if you're to see plentiful shooting stars, but the rest of it is down to luck. In 2021 only three meteor showers will reach peak activity when the Moon is out of the way. As luck would have it, one of them is the Perseids, perhaps the best-loved and most comfortably observed of them all. There will be almost no moonlight interference for August's Perseids and October's Draconids and Southern Taurids, though December's Geminids will peak during a first quarter Moon, and both October's Orionids, November's Leonids and December's Ursids peak close to a full Moon.

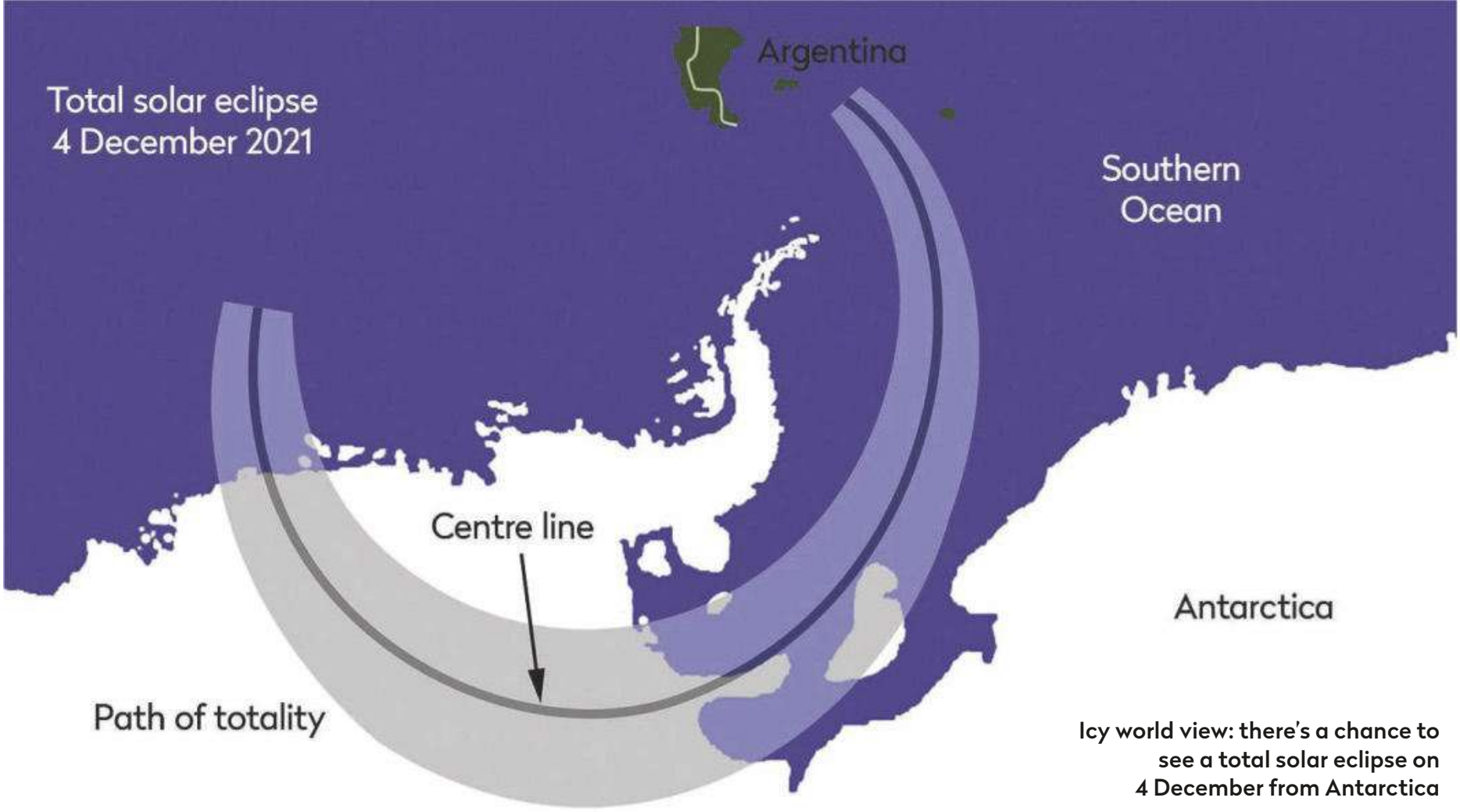
"The best time for observing most meteor showers is after midnight, because Earth is turning towards it and moving into the shower of cosmic debris at a higher speed," says Henbest. "You'll get more meteors after midnight, and they'll generally be brighter." For the same reason, early morning is best.

It is Earth's passage through this debris that causes meteor showers. Sometimes there will be a clump of debris that unexpectedly collides with Earth's atmosphere. "It doesn't often happen, but sometimes the best displays of meteors might occur at different times to the predicted peak," says Henbest. "So it's worth looking the night before and the night after as well."

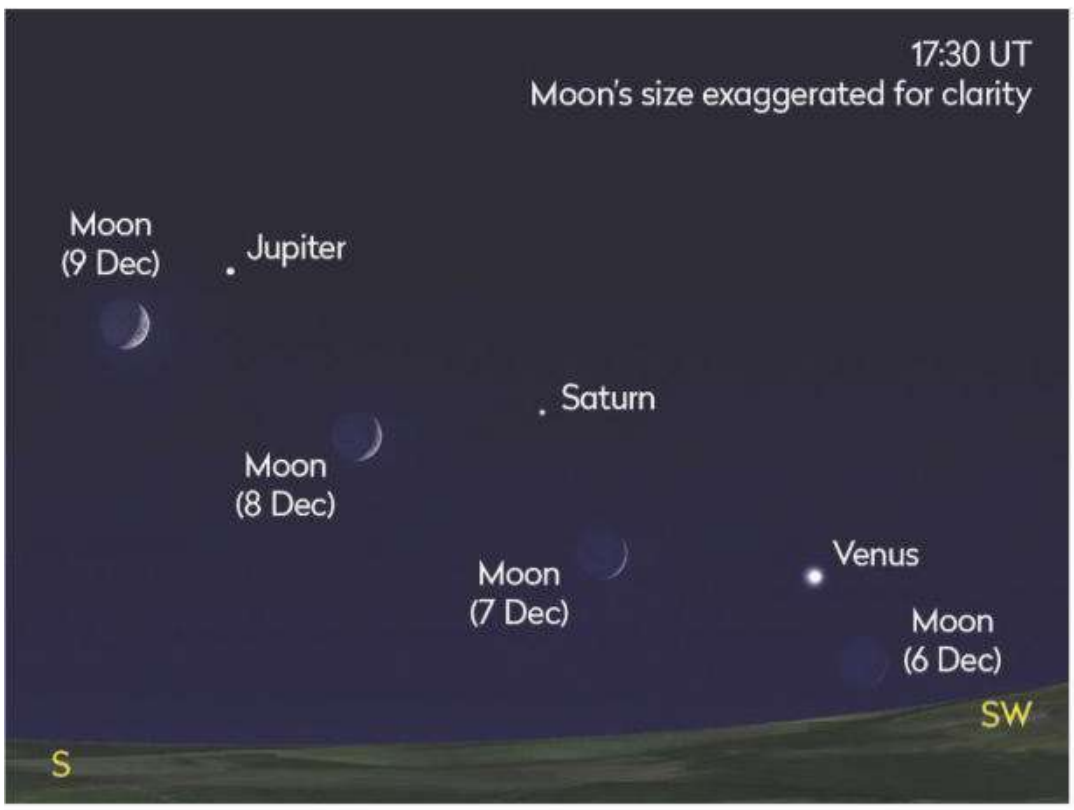
Perseids
Peak: 12-13 August
Max. meteors/hour (ZHR): 110
Moon phase: New Moon on 8 August

Draconids
Peak: 8-9 October
Max. meteors/hour (ZHR): 10
Moon phase: New Moon on 6 October

Southern Taurids
Peak: 10-11 October
Max. meteors/hour (ZHR): 5
Moon phase: New Moon on 6 October



Icy world view: there's a chance to see a total solar eclipse on 4 December from Antarctica



▲ Follow the planets marching across the night sky in early December

world that rotates on its side takes 84 years to orbit the Sun, so its position doesn't change much from year to year. Best viewed through a small telescope around midnight when it's high in the southern night sky, Uranus in 2021 is on the outskirts of the constellation of Aries, the Ram, but just as close to Taurus, the Bull, and Cetus, the Whale.

19. Totality on the White Continent

When: 7:33 UT, 4 December
Where: Antarctica

There are few affordable options for this intrepid eclipse chase. The first totality on Antarctica in the age of mass tourism will occur early in the morning when the Sun is barely above the horizon during a time of near-constant daylight (see above, top), so it promises to be the darkest 1 minute 40 seconds of the entire trip for anyone on a cruise ship close to the South Orkney Islands at around 60° S.

20. A parade of planets

When: just after sunset on 6, 7, 8, 9 December
Where: low on the western horizon

Jamie Carter is a science and astronomy writer and author of *A Stargazing Program for Beginners: A Pocket Field Guide*

As 2021 draws to a close there will be a parade of planets right after dark (see left). With the Sun gone from the sky, Jupiter will be shining high in the south and Venus low in the southwest, with Saturn in between. Better still, a slim crescent Moon will make its way through the trio on successive evenings, visiting Venus on 6 December when 8%-lit, splitting Venus and Saturn on 7 December as a 16%-lit crescent, and splitting Saturn and Jupiter on 8 December while 25%-lit. Finally, on 9 December a 35%-lit Moon will be in conjunction with Jupiter.

21. The 'Winter Hexagon' at its best

When: December-February
Where: highest around midnight

Here's an asterism (an informal shape rather than an official constellation) of the brightest stars in the winter night sky (see below), taking us into early 2022. Going clockwise from the bright star Sirius (Alpha (α) Canis Majoris) closest to the horizon, is Procyon (Alpha (α) Canis Minoris), then the bright stars Castor (Alpha (α) Geminorum) and Pollux (Beta (β) Geminorum), across to Capella (Alpha (α) Aurigae), down to red star Aldebaran (Alpha (α) Tauri), then Rigel (Beta (β) Orionis) under Orion's Belt, and back to Sirius.

ESENTUNAR, GETTY

The Winter Hexagon, best seen from December to February

Landscaping worlds: this stunning view of an exoplanet seen from its moon is just one of the many incredible artworks created by data visualisation artist Luís Calçada

PICTURING SPACE

Will Gater meets the people who work behind the scenes to create the astronomical imagery accompanying the headlines

From his office on the outskirts of the leafy town of Garching – near Munich, Germany – Luís Calçada has spent the last 14 years opening windows onto the Universe. He's built black holes and brought entire planetary systems into existence. And it's all been done from in front of a computer screen.

That's because Calçada is one of a number of scientists and visualisation experts scattered around the world whose job is to create astronomical imagery for space agencies and observatories. Whether they process the observations from space or ground-based telescopes themselves to create beautiful astro images, or use them as inspiration to create artists' impressions, the end results are spectacular.

Though their pictures may enter the world attached to a press release, they've spread far and wide through public life. They've inspired art and some – like the Martian rovers' selfies – have even become modern-day icons of scientific advancement. But behind these extraordinary pictures is a rarely explored story – that of the work that brings them to life.

State of the art

Calçada currently works as a data visualisation artist for the European Southern Observatory creating astronomical illustrations guided by data, but built from his own imagination. Initially, though, he planned to become a professional astronomer.

"To support my studies I started working in a planetarium doing a bit of everything," he says. "We needed some images so I started fiddling with some very basic 3D programmes just out of curiosity."

Today Calçada's artistic skills typically come into play when the ESO press team are preparing to announce a new result or discovery to the world. But in the case of professional 'outreach' astro images – the beautiful views of galaxies and swirling nebulae created using real data captured by orbiting or ground-based observatories – their beginnings are usually to be found in the research they often go on to publicise. It can be ▸

▲ **This spectacular image of the centre of the Milky Way was created by combining data from the Chandra (blue and violet), Hubble (yellow) and Spitzer (red) space telescopes**

► a long journey too, from photons falling on a sensor to pictures on a computer screen.

For NASA's Chandra X-ray Observatory and other orbiting missions like it, the process of getting information from a telescope into the hands of scientists starts when the raw data is beamed home.

"The data are sent from the observatory down to Earth through what's called the Deep Space Network, a series of telescopes around the world that allows us to communicate with telescopes and other instruments in space," explains Dr Kimberly Kowal Arcand, a visualisation scientist working on data from the Chandra mission. "Both humans and machines check the data, including removing the effects of the spacecraft moving through space, and making sure nothing went awry in gathering the data. Once all of that happens successfully, the data can be delivered to the scientists who proposed that observation."

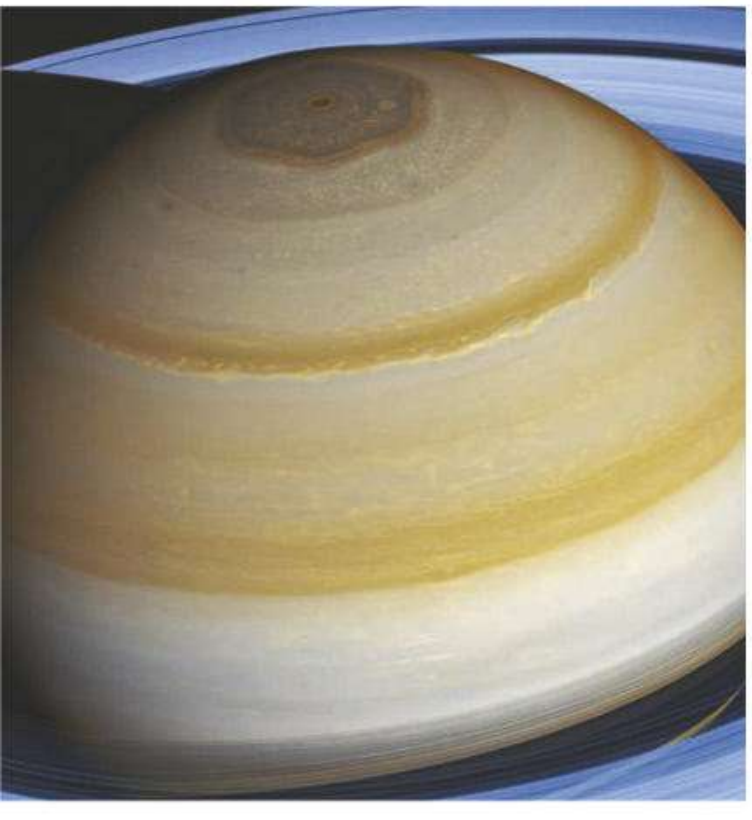
It's not just space telescopes that have these routines either; robotic missions exploring the other worlds in our Solar System do too.

Kevin Gill is a software engineer at the Jet Propulsion Laboratory who has processed outreach imagery for NASA, including data from the Cassini mission to Saturn. Today one of his roles at the California-based lab is to also check on the images returning home from the InSight lander on Mars. "When the data comes down it's in data packets," he says. "So we have to take those, make sure they're all there and assemble them into the raw image."

A fine art

NASA's Solar System missions typically have large, dedicated teams working on the production and analysis of pictures from each spacecraft. Such views are part of the medley of scientific data returned by these spacecraft, and are a key source of insight for researchers. Indeed, it's true that much of the professional astro imagery we see is gathered primarily for academic study. However, it's when that data is used to create outreach images, that the worlds of art and science begin to blend with stunning effect. ►

▼ **Below, left and right: two of Kevin Gill's many stunning images of Saturn, processed from data captured by the Cassini spacecraft**



Behind the images

From cosmic visions to press release visualisations, we discover how those pictures came to be

X-RAY: NASA/CXC/UMASS/D. WANG ET AL/OPTICAL: NASA/ESA/STSCI/DWANG ET AL/IR: NASA/JPL-CALTECH/SSC/S.STOLOVY, NASA/JPL-CALTECH/SSI/CICLOPS/KEVIN M. GILL X 2, X-RAY: NASA/CXC/CFA/M.MARKEVITCH ET AL/OPTICAL: NASA/STSCI; MAGELLAN/U.ARIZONA/D.CLOWE ET AL/ LENSING MAP: NASA/STSCI/ESO WFI/MAGELLAN/U.ARIZONA/D.CLOWE ET AL, ESO/L. CALÇADA, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE

Bringing the Bullet Cluster to life

"This image of the Bullet Cluster of galaxies actually provided the first direct proof of dark matter. I worked with Zolt Levay, Hubble's image expert at the time, to create this image, and we went through a series of iterations of different colour mappings. At one time we had the X-rays in blue and the [gravitational] lensing map in pink, and it just didn't work. So we reversed the colour scheme to be as you see it now. I don't think we quite realised that we would be setting a standard of sorts for these types of images for years to come."
Kimberly Kowal Arcand

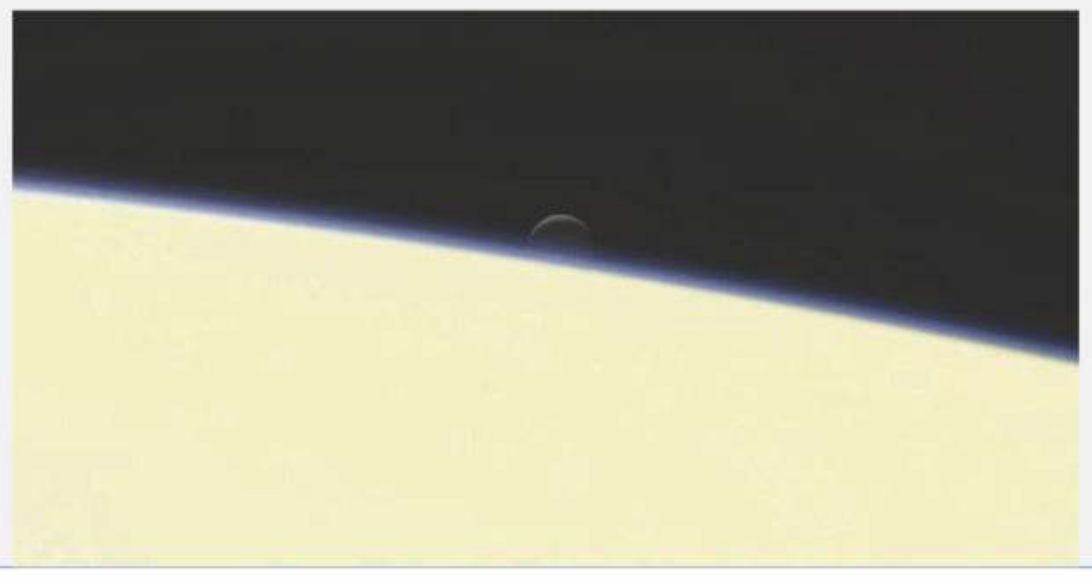
ILLUSTRATION

Imagining Pluto

"I did this illustration 11 years ago and at the time we had no images, or very poor images, of Pluto and had to come up with something [for a press release]. I worked with Olivier Hainaut, one of the scientists at ESO (the European Southern Observatory), and he said we should have these ice patches. When we observed the first images from New Horizons of Pluto, I was like, 'Yeah, it looks so close to what we have done!' It was really cool. With most of the illustrations we make, we will very rarely have the chance to actually compare them with a direct observation."
Luís Calçada

A last look at Enceladus

"[This was captured] during the descent into Saturn, on Cassini's last orbit. It was just fun because on the last day we had the media there at JPL and I was going to be processing those final images. I was waiting all day for those to come down. While the media went off to watch the final signal [from the spacecraft] I actually came home and was just sitting on the couch working on the images. I sent them off to the JPL media office so they could include them in the press releases that morning."
Kevin Gill



▸ "The primary motivator is to tell the science story of the data accurately, but we try also to present them in a way that is both engaging and aesthetically pleasing," explains Arcand.

One of the challenges Calçada says he faces when making artist's impressions, is that people often have a pre-conceived notion of what space should look like, based on movies and television shows. "We're kind of fighting with that because we want to try to keep it real," he says.

Balancing expectations with realism is one of many elements in a professional image processor's work. Another challenge, which will be familiar to amateur astrophotographers, is the task of deciding how to display and portray phenomena we can't actually see.

"In some ways we must turn something that is invisible into something visible," says Arcand. For data from space telescopes, like the X-ray-observing Chandra, this can sometimes mean blending the images with views from other missions observing at different wavelengths. "Even though we are working with data that can't be changed, there are many ways to frame that information," explains Arcand. "We ask questions like: how might this information best be served? In a simple 2D image with only X-ray light? Or should we tell the story using the X-rays combined with an image from an optical light or radio telescope?"

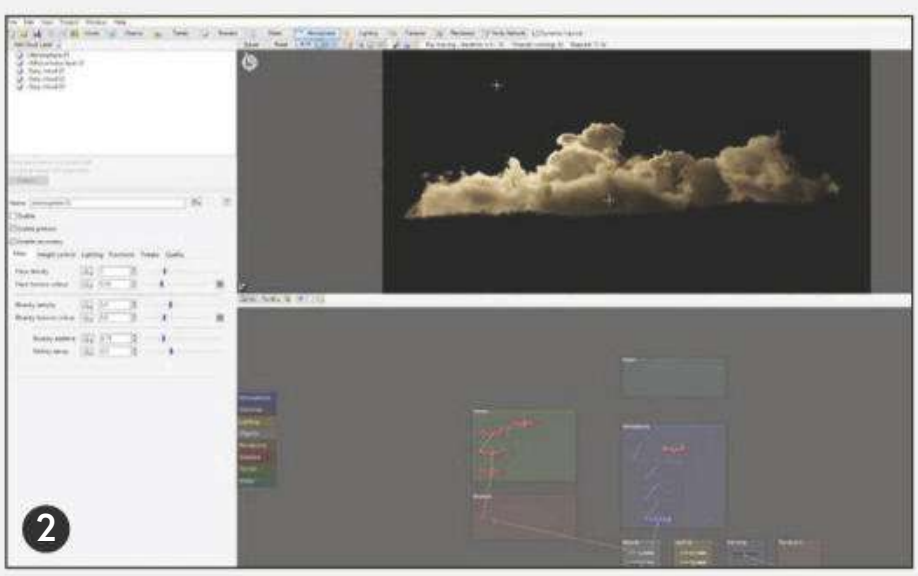
Producing a Chandra image often begins with

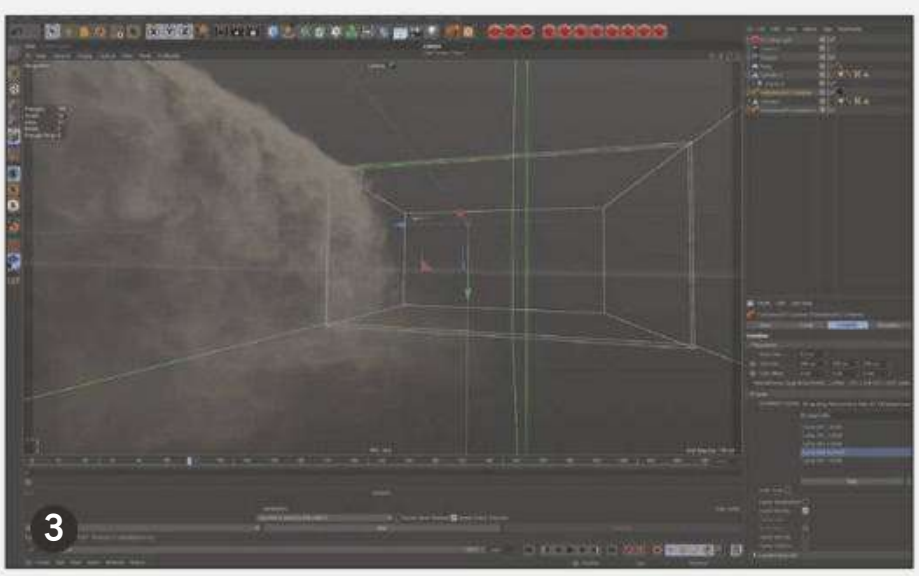
Creating cosmic vistas

The steps involved in producing an artist's impression of an alien world

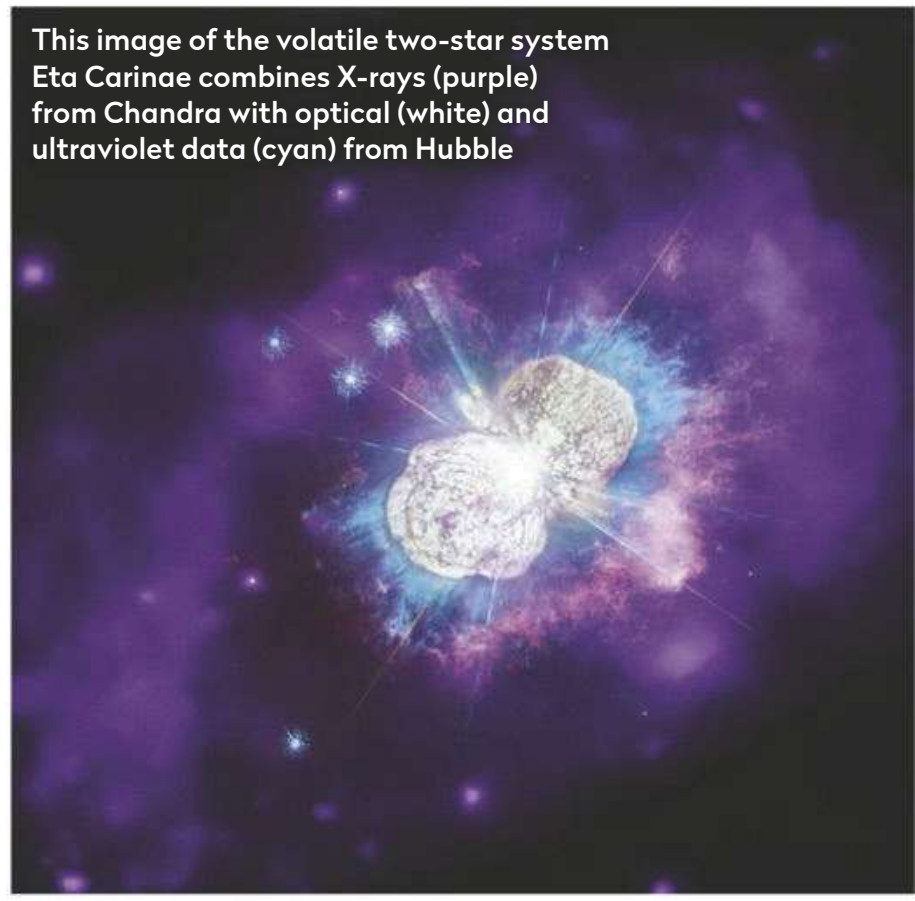
This artist's illustration was created for a European Southern Observatory press release by ESO visualisation experts Martin Kornmesser and Luís Calçada. It depicts a rain of molten iron falling from the sky on the extrasolar planet WASP-76b. "The planet was tidally locked so [the astronomers] knew that there must be a very specific area where we go from very hot to very cold," explains Calçada. "They detected iron so they were sure that iron would condense in this area."

The idea for the wall of clouds (1) came from when the pair were being briefed on the project and a realisation that there would likely be large cloud structures on the terminator of the exoplanet. Kornmesser painted the scene in Photoshop while Calçada supplied simulated 3D features to be incorporated into the picture, such as clouds. These were carefully rendered in the software Terragen (2) and Cinema 4D to match the perspective (3) in Kornmesser's painting.





One of Kevin Gill's Jupiter images, processed from data taken by the Juno spacecraft



This image of the volatile two-star system Eta Carinae combines X-rays (purple) from Chandra with optical (white) and ultraviolet data (cyan) from Hubble

Will Gater is an astronomy journalist and science presenter. His latest book, *The Mysteries of the Universe*, has recently been published by DK

an image format known as a FITS file. It's a format that you may recognise, as it's the file type typically produced by the CCD cameras commonly used for amateur deep-sky imaging.

"The key next step is to bring the data into a package that bridges the scientific and aesthetic perspectives and provides more minute control over the processing and results," says Arcand. "For that, FITS Liberator, a plug-in for Photoshop, is ideal. We work on the image curves and levels, join multi-wavelength layers, adjust colours, and so on."

Some missions require quite complex data workflows. For instance, when Gill is working on images sent back by the Juno mission to Jupiter, he has to use specialist software to re-project the raw imagery from the probe into stunning vistas of the Jovian cloud tops. Yet amid the technical processing work there are still artistic choices to be made.

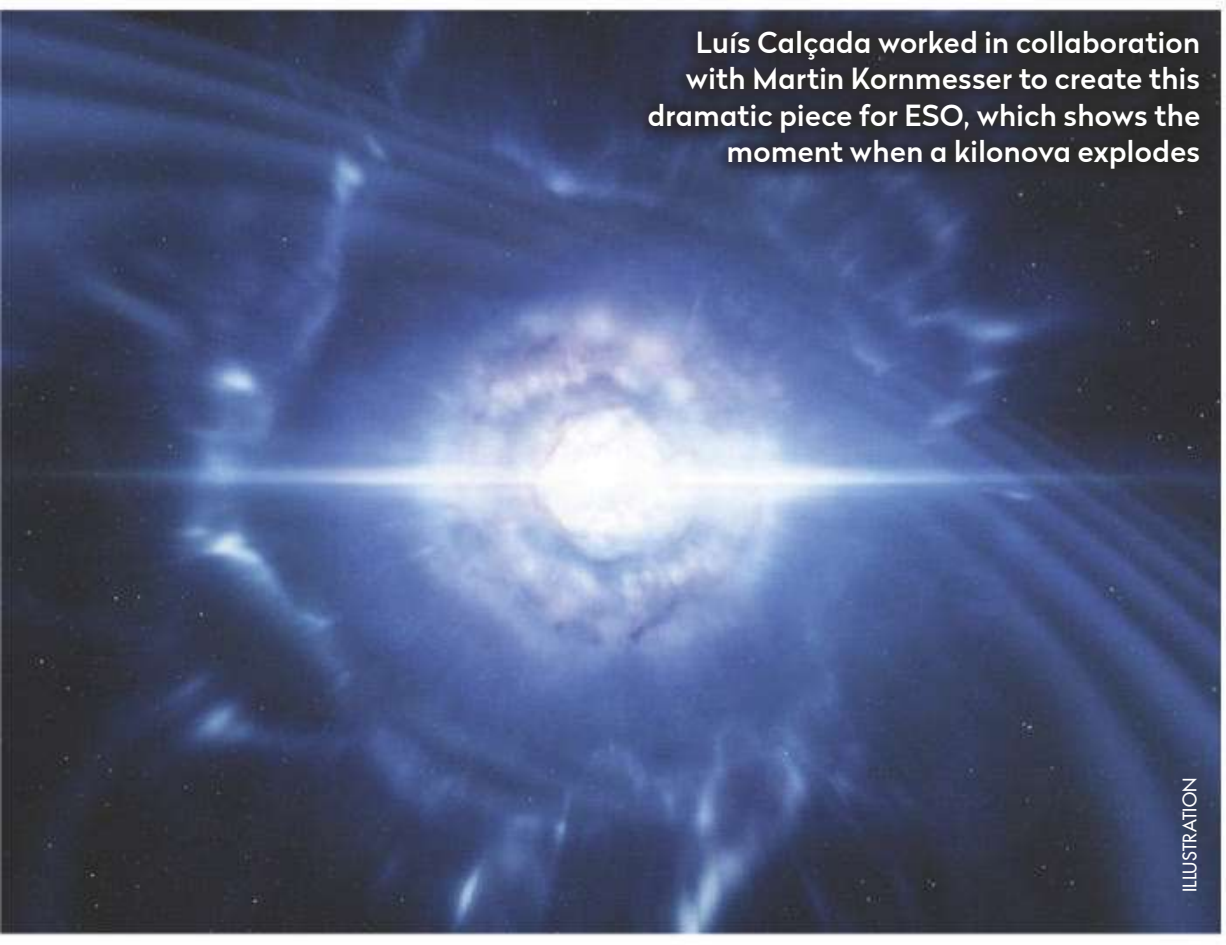
"Do I want to focus on the details in the lower atmosphere or show the hazes above it?" says Gill. He also has to be careful when sharpening an image not to introduce detail that isn't real. Similar care is required when removing noise. "You don't want to make anything look unnaturally smooth."

Often the scientists whose research is being showcased or promoted through the outreach images will provide feedback on the pictures before they are released to the world. With Calçada's artist's impressions, researchers will occasionally suggest tweaks relating to the science of what's shown, for example the colour something might be based on its temperature or how many starspots a star has given its age and activity.

Gill's planetary work has even led to him being asked to re-process archival NASA images, such as last year's re-release of Voyager 1's iconic 'Pale Blue Dot' photograph.

In fact a vast amount of raw image data, from various space missions and orbiting telescopes, is today freely available through online archives like NASA's Planetary Data System (**https://pds.nasa.gov**) and the Hubble Legacy Archive (**https://hla.stsci.edu**). Anyone with a computer and image-editing software like Photoshop or GIMP can have a go at producing their own takes on some of the views released by space agencies and other organisations over the decades. If you're like Gill – who began as a hobbyist and has recently been invited to join a team taking pictures with the Mars rover Curiosity – it could take you to some remarkable places.

You can enter your own processed images for the Annie Maunder Prize for Image Innovation in this year's Astronomy Photographer of the Year awards. Turn the page for details. ▶



Luís Calçada worked in collaboration with Martin Kornmesser to create this dramatic piece for ESO, which shows the moment when a kilonova explodes

ILLUSTRATION

ESO/M. KORNMESSER/L. CALÇADA X 3, NASA/JPL-CALTECH/SWRI/MSSS/KEVIN M. GILL, X-RAY: NASA/CXC/ULTRAVIOLET/OPTICAL: NASA/STSCICOMBINED IMAGE: NASA/ESA/N. SMITH (UNIVERSITY OF ARIZONA), J. MORSE (BOLDLYGO INSTITUTE) AND A. PAGAN, ESO/L. CALÇADA/M. KORNMESSER

▲ Nicolas Lefaudeux won the 2020 competition with this image 'Andromeda Galaxy at Arm's Length?'

Astronomy Photographer of the Year

The world-class competition returns to seek out the best astronomy image of the last year

The Astronomy Photographer of the Year Awards are open for entries once again with a grand prize of £10,000 up for grabs. For 13 years, the competition has sought out images which blend technical skill with an artistic eye and create a captivating view of the Universe – and this year promises to be one of the most unique in the competition's history. Although travel restrictions may have prevented astrophotographers travelling to their usual favourite imaging spots, it hasn't stopped them from capturing the cosmos on camera. And there's been no shortage of inspiration either, as 2020 has provided two once-in-a-lifetime photo opportunities in the Great Conjunction of Saturn and Jupiter in December, and Comet NEOWISE's visit in the summer.

It's also been a year that's seen many people taking up stargazing and astrophotography as a way to find solace in the turmoil of the pandemic. Don't be put off from entering just because you haven't been doing it for long – the Patrick Moore Prize for Best Newcomer celebrates those who are just starting out.

Alternatively, if you are more into processing data gathered by professional telescopes and space missions, the Annie Maunder Prize for Image Innovation might be the one for you.

Whether beginner or expert, the £10 entrance fee allows you to enter up to 10 images into any of the main categories listed opposite, as long as your image was taken after 1 January 2020. A panel of judges will then select the best images and announce the winners on 16 September 2021. Good luck!

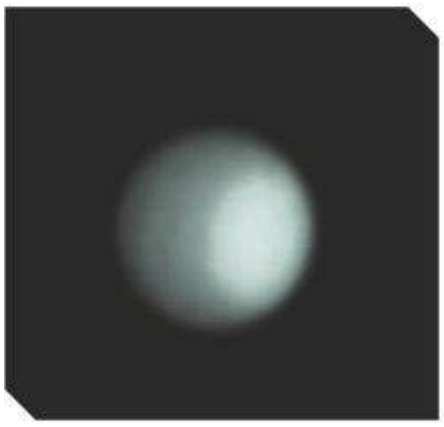
Dates for the diary

Competition opens: 11 January 2021
Closing date for entries: 5 March 2021
Entrance fee: £10 for up to 10 images

How to enter and rules:
To read the rules, and put yourself in the running to become Astronomy Photographer of the Year 2021, visit the competition website:
http://apy.rmg.co.uk

CATEGORIES

There are many categories to choose from and you can enter multiple times



Planets, Comets and Asteroids

With the Great Conjunction and Comet NEOWISE offering fantastic photo opportunities, this category looks set to be one of this year's most hotly contested.

Aurorae

Getting out to see the aurora has been a challenge this year – unless you happen to live in the auroral oval – but if you did manage to capture images in 2020, be sure to enter them.

People and Space

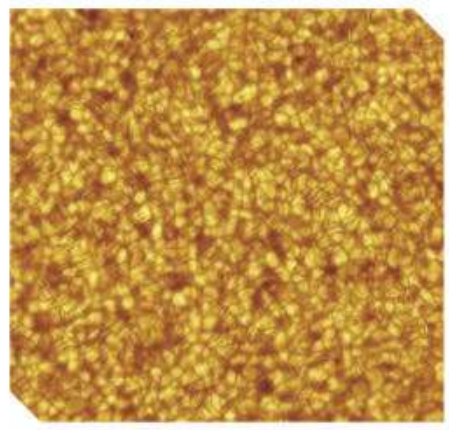
This year more than ever, we have felt the need to connect with the cosmos. This category celebrates images showing people or their influence on the night sky.

Skyscapes

If you have an image which showcases the celestial sights against an earthly foreground – be it a tree-lined horizon or a built-up cityscape – it belongs in this category.

Our Moon

The ever-changing face of the Moon offers a host of photo opportunities. Whether the whole disc or a crater close-up, enter your lunar images here.



Our Sun

The Sun is just beginning to wake up after going through the slump of its 11-year solar cycle. Enter images of its increasing activity here.

Stars and Nebulae

From a sparkling constellation to a colourful nebulae, there are countless beautiful sights within the Milky Way that are ripe for this prize.

Galaxies

The Universe is filled with billions of galaxies and, though we can only see a small handful of these, there are still hundreds to choose from.

Young Astronomy Photographer of the Year

Helping to foster the astrophotography talent of tomorrow, this category is open to anyone aged 15 and under by the closing date.

Special Prize: Patrick Moore Prize for Best Newcomer

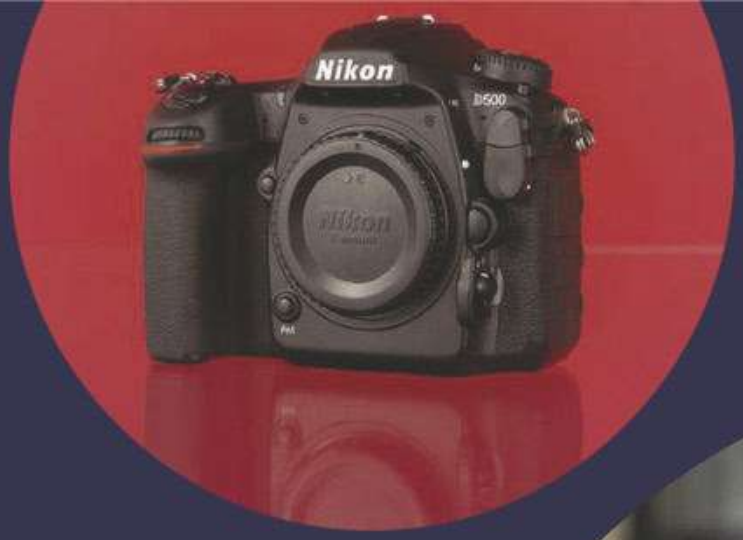
Don't be put off from entering if you're new to astrophotography; this prize is for those who first turned their cameras to the sky this year.

Special Prize: Annie Maunder Prize for Image Innovation

This special prize asks entrants to use data from professional sources and process them in an innovative way. Last year saw entrants creating beautiful false-colour images, combining data from multiple observatories and even, in the case of last year's winner, printing out high-resolution images and creating a sculpture with them. Can you come up with an even more unique way to show off the Universe?

NICOLAS LEFAUDEUX, MARTIN LEWIS, NICHOLAS ROEMMELT, TIAN LI, THOMAS KAST, ETHAN ROBERTS, ALEXANDRA HART, PETER WARD, MARK HANSON, ALICE FOCK-HANG, BENCE TOTH, JULIE HILL

Change gear.



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Make. Good. Use.

Make good use of your used gear. Clear out your kitbag and cabinets, and sell what you're not using to free up funds or trade in towards your next kit purchase.

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BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

The Sky Guide

FEBRUARY 2020

THIN MOON RISING

Catch a gorgeous waxing crescent Moon on 12 February

MARS MEETS THE PLEIADES

Observe the Red Planet as it approaches the beautiful star cluster

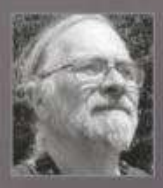
A TRICK OF THE LIGHT

Spot the Moon's clair-obscur effect known as the Jewelled Handle

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Venus and Jupiter only half a degree apart
- ✦ Minor planet 29 Amphitrite at opposition
- ✦ Lunar crater Endymion in a favourable libration

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

FEBRUARY HIGHLIGHTS

Your guide to the night sky this month

Monday

1 A telescopic view of Mars as the sky is darkening at 18:30 UT will show Mare Sirenum locaated slightly south of centre. The giant Olympus Mons volcano sits to the north of this dark mare.

Tuesday ▶

2 This morning's 77%-lit waning gibbous Moon passes just 1.2° from the binary star Porrima (Gamma (γ) Virginis).

Saturday

6 If you're up early today, look towards the southeast where you'll see a 33%-lit waning crescent Moon sitting 5.3° north of mag. +1.0 Antares (Alpha (α) Scorpii).

Thursday

11 A tricky spot in the morning sky, Venus and Jupiter are half a degree apart and rise 15 minutes before the Sun. A daytime view would be easier, but only attempt this if you can protect your view from the glare of the Sun.

Friday ▶

12 Although not optimally positioned, it may be possible to spot a 1%-lit waxing lunar crescent this evening. From the UK this very thin Moon will be located above the west-southwest horizon, to the left of the position where the Sun has set.

Saturday

13 If you missed yesterday's very thin Moon, try again today. The now 4%-lit waxing crescent should be easier to see above the west-southwest horizon approximately 50 minutes after sunset.

Thursday

18 As we approach midnight UT, the 41%-lit waxing crescent Moon sits a little over 4° from mag. +0.7 Mars.

Friday ▶

19 This evening's first quarter Moon sits close to the Pleiades and Hyades open clusters in Taurus. A telescopic view of the Moon just after 23:00 UT shows the peaks of the central mountains in crater Aristillus illuminated like a small star cluster.

Family stargazing

Spotting thin evening Moons is fun and time-friendly; you'll typically need to be in position, looking towards the west-southwest 20–30 minutes after sunset. The thin Moons on 13–15 February will be easiest for young eyes. Make sure the Sun has set, then see who can spot the thin Moon crescent first. On the 14th or 15th as the sky darkens, see if you can view the weak glowing night side of the Moon. Explain that this is due to light reflected by Earth illuminating the Moon's night side; a phenomenon known as 'earthshine' or the 'old Moon in the young Moon's arms'. **www.bbc.co.uk/cbeebies/shows/stargazing**

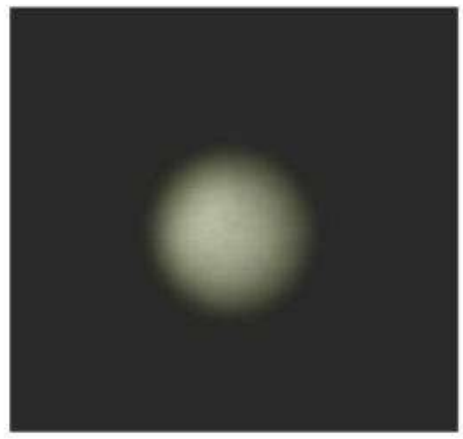
PETE LAWRENCE X 6

Wednesday 3

With the Moon in the morning sky, this is an excellent time to investigate the myriad deep-sky objects located in and around Orion, the Hunter, such as M78 shown here. Orion is highest early evening, around 20:30 UT.

Tuesday 16

Mag. +0.7 Mars sits 27 arcminutes south of mag. +4.3 Botein (Delta (δ) Arietis) this evening.



◀ Wednesday 17

This evening's 31%-lit waxing crescent Moon sits 3.2° south of mag. +5.8 Uranus.

Sunday 21

A telescope or binocular view of the Moon, seen at around midnight UT, will show the clair-obscur effect known as the Jewelled Handle. It's caused when the mountain range bordering Sinus Iridum catches the lunar dawn.

Monday 22

Minor planet 29 Amphitrite is at opposition today, shining at mag. +9.1 in the constellation of Leo. Turn to page 53 for more information.

Tuesday 23

A telescopic view of this evening's Moon will reveal a bright star-like dot to the west of the bright crater Aristarchus. This dot is a clair-obscur effect called the Star-Tipped Mountain.

Thursday 25

This evening and tomorrow evening are favourable times for viewing the Moon's southwest limb, the location of the Mare Orientale. As full Moon approaches, libration will tilt this part of the Moon towards us as the terminator marches across it.

Saturday 27

Mars is beginning a southern track below the Pleiades open star cluster. The mag. +0.9 planet is currently located 3.8° southeast of the cluster's centre.

Friday 28

Mag. +0.4 Mercury and –1.8 Jupiter are just 3° apart this morning. A tricky spot low above the southeast horizon, both planets rise approximately 40 minutes before the Sun.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

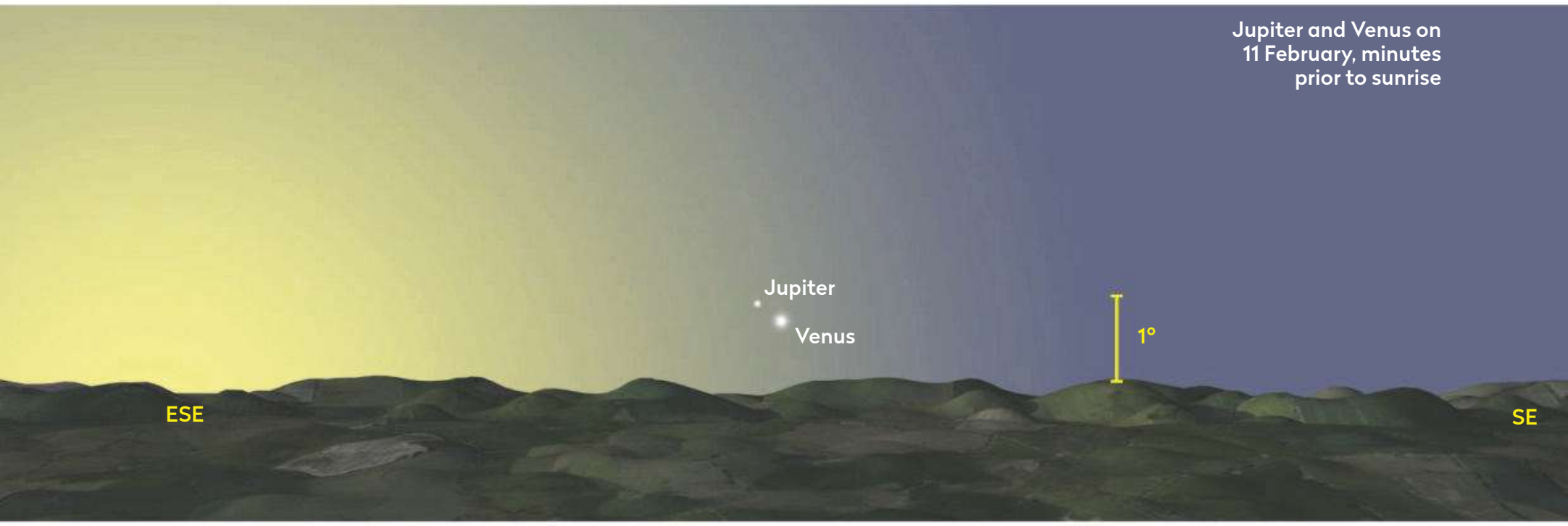
Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The three top sights to observe or image this month



DON'T MISS

Venus and Jupiter conjunction

BEST TIME TO SEE:
Venus-Saturn on 6 February; Venus-Jupiter on 11 February

Jupiter and Saturn are slowly emerging into the morning sky, having reached conjunction with the Sun on 23 and 29 January respectively. Dazzling Venus has been visible in the morning sky since June 2020. This month there will be two close and somewhat challenging conjunctions between Venus, Jupiter and Saturn.

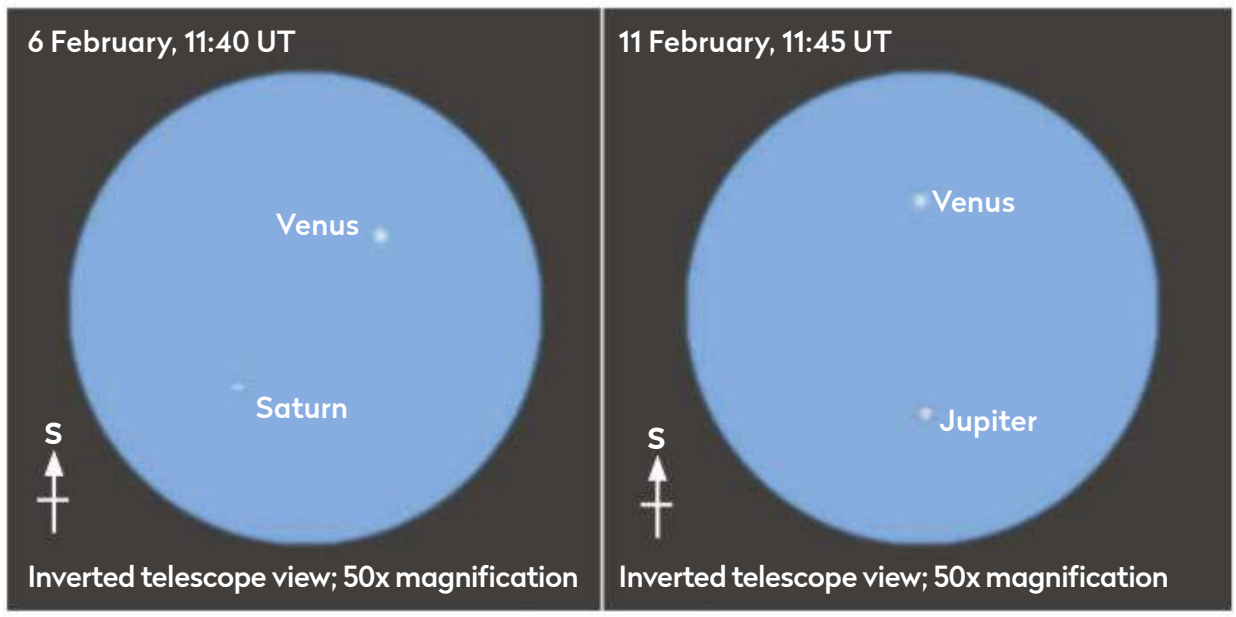
It's Saturn's turn first, Venus and Saturn appearing just 23 arcminutes apart on the morning of 6 February. Jupiter's close encounter follows on the 11th, when both planets are 31.5 arcminutes apart.

The challenging element occurs because all three planets are awkwardly positioned from the UK, rising less than 30 minutes before sunrise. While mag. –3.8 Venus stands out against a bright twilight sky, it's unlikely that mag. +0.9 Saturn will be able to do the same. It's even questionable whether mag. –1.8 Jupiter will be that easy as a low altitude object in a bright February morning sky. If you want to give it a try with the naked eye or using binoculars, the conjunctions rise above the southeast horizon approximately 20 minutes before sunrise. Extreme care needs to be taken to ensure you don't inadvertently look at the Sun. Whatever you do, it's imperative to stop looking if the Sun has appeared above the horizon.

At this point you might be forgiven for thinking we've introduced you to two conjunctions you can't see! While this may be the case for the naked eye, if you have the ability to locate Venus during the day, this changes the game. It is possible to see Saturn under daylight conditions, but it's tricky at best. Being dim, it appears with extremely low contrast. As a consequence, and considering it's a low object from the UK anyway at the moment, a clear, crisp February sky is needed to stand a chance.

Jupiter is a better prospect, but even at mag. –1.8 it too can appear faint under blue-sky conditions. The location of Venus near to both gas giants is a huge bonus because Venus is relatively easy to see in daylight. There are various techniques which can be used to spot it with a telescope during the day. Filtering your telescope for solar viewing, centring on the Sun's disc and using setting circles to offset to Venus is one method.

Alternatively, some Go-To systems will allow you to slew to Venus using the filtered Sun as a navigational starting point. If this is not possible, a Go-To mount set up during the previous night and left on may be the way to go. If you don't have Go-To, but can locate Venus soon after rising, it should then be possible to stay with the planet until it has gained additional altitude.



▲ Venus and Saturn are due south at 11:40 UT on 6 February, with an altitude around 17°. Then on the 11th Venus and Jupiter are due south at 11:45 UT with an altitude around 19°

ALL PICTURES: PETE LAWRENCE

Thin Moon spotting

BEST TIME TO SEE:
Post sunset on 12–15 February

The year 2021 looks like a good one for thin Moon spotters with a number of very thin waxing and waning lunar crescents on display. Multiple opportunities are good news, because one element that typically thwarts thin Moon spotters is the weather! Assuming it's clear on 12 February, it may be possible to see a 1%-lit waxing lunar crescent low above the west-southwest horizon just after sunset.

This Moon is only above the horizon for 40 minutes after the Sun has set, so you'll need to be quick to spot it. Binoculars are the best tool here, but ensure the Sun has properly set before trying. Don't expect this to be easy, as the 1%-lit crescent Moon will be appearing against a bright twilight sky and won't be particularly bright itself.

If you struggle with the waxing crescent on the 12th, don't feel too bad, as it's genuinely difficult to see. On the following evening, the 13th, the now 4%-lit waxing crescent should be a lot easier as it remains above the horizon for two hours after sunset. This means the Moon will stand out better against a darker sky.

If it's clear on the 14th, the now 9%-lit waxing crescent Moon should be obvious. This is often a lovely sight due to the Moon's night side glowing gently from the earthshine – light reflected from Earth.

A 1%-lit waxing crescent Moon should be visible from 15 minutes after sunset on 12 February, 2.5° above the west-southwest horizon

If you're new to thin Moon spotting, the difficulty of seeing ultra-thin lunar crescents around 1%-lit may be a surprise. However, it's worth persisting to try and see or photograph one. As mentioned, there will be a number of good opportunities in 2021, some in the evening sky and some in the morning sky, so your chances for seeing at least one should be promising.

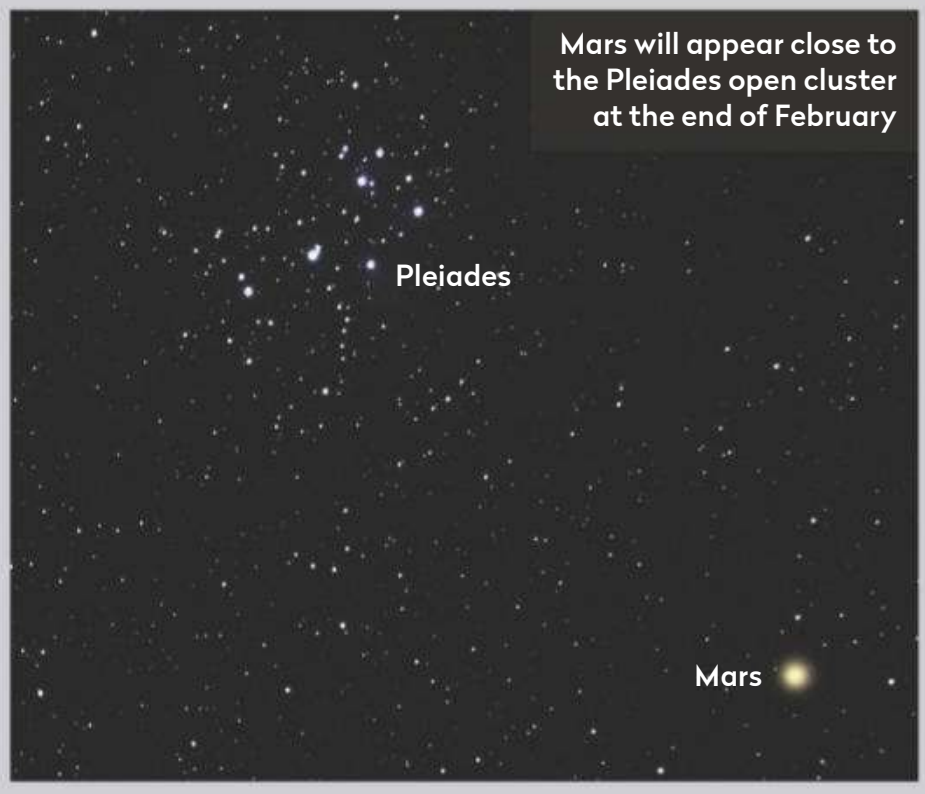
Mars approaches the Pleiades

BEST TIME TO SEE: Last week of February

It's sad to see Mars fading. Its mag. +0.5 appearance at the start of February is a far cry from the brilliant mag. –2.6 it got to in October 2020. However, the planet remains interesting to watch with the naked eye over the February to March period as it will be passing just south of the Pleiades open cluster, M45. At the start of February, Mars is in southern Aries, approximately mid-way between Hamal (Alpha (α) Arietis) and Menkar (Alpha (α) Ceti). Despite its diminished brightness, the planet's orange hue will still be obvious.

As February slips by, Mars nudges further east. On the evening of the 16th, mag. +0.7 Mars passes 27 arcminutes south of mag. +4.3 Delta (δ) Arietis. A 40%-lit waxing crescent Moon joins Mars on the evening of the 18th, the Moon's disc being 5° below the planet early in the evening.

Mars moves from Aries into Taurus on 23/24 February, but is unable to reach its highest position in the sky, due south in darkness. Despite this, it remains the most northerly planet, managing to appear 55° up as darkness falls.



Mars will appear close to the Pleiades open cluster at the end of February

As we approach the end of the month, Mars appears near the Pleiades open cluster. Early evening on the 28th, the mag. +0.9 Red Planet sits just 3.4° south of this beautiful cluster.

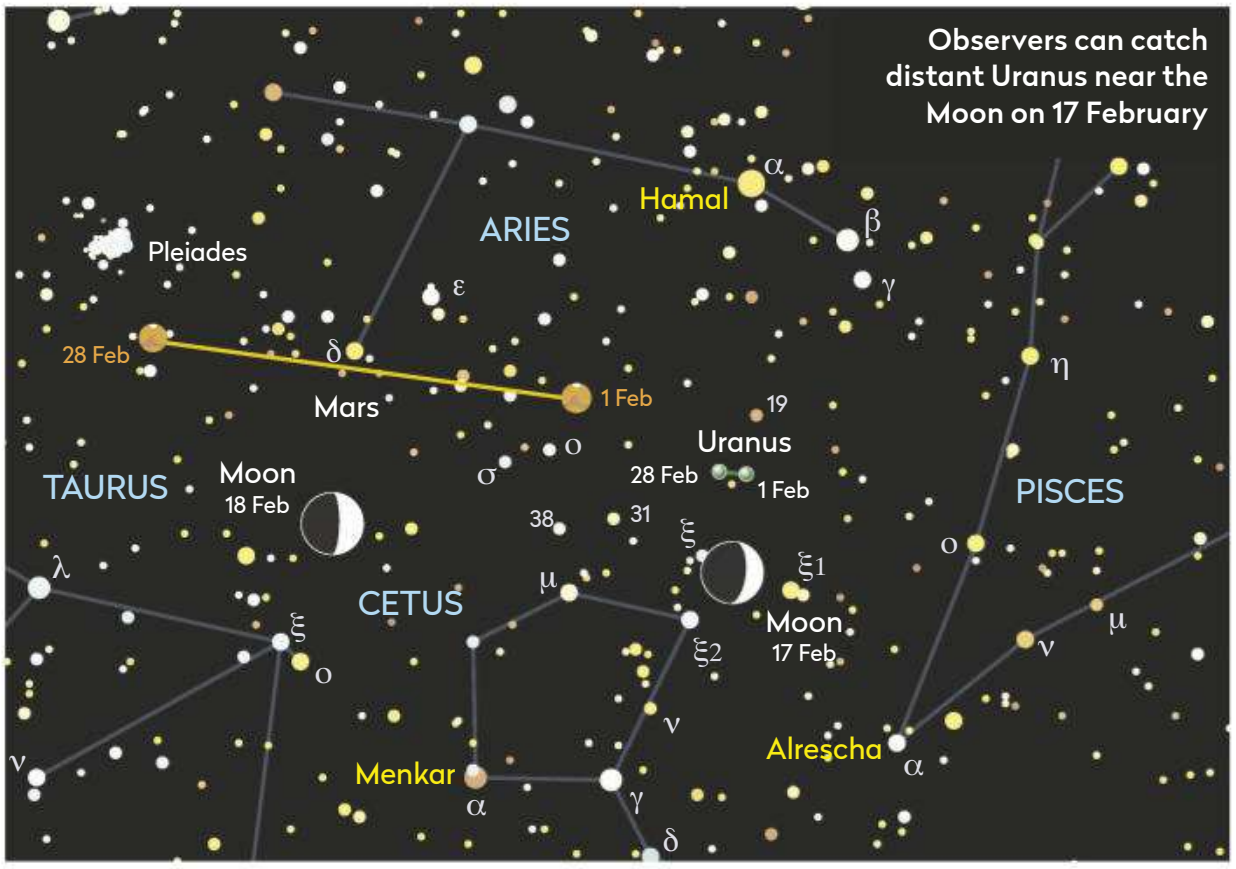
THE PLANETS

Our celestial neighbourhood in February

PICK OF THE MONTH

Uranus

Best time to see: 1 February, 18:50 UT
Altitude: 48°
Location: Aries
Direction: Southwest
Features: Colour, moons, subtle banded atmosphere
Recommended equipment: 150mm or larger



Uranus is now losing altitude as true darkness falls, the evening twilight rapidly expanding to encompass the planet. Having said this, the ice giant still manages a healthy altitude of 46° from the centre of the UK in darkness at the start of the month, a figure which drops to 30° by the end of the month. February therefore presents a last-chance opportunity to grab a view of this distant world before it's engulfed by the evening twilight, not to return to UK dark skies until next autumn.

Despite having a diameter of 50,700km, at its great distance of 19.9 AU Uranus presents a tiny disc, just 3.5 arcseconds across. This is about three times the apparent diameter of Jupiter's largest moon, Ganymede as it appears from Earth. There's not a lot of detail visible on Uranus's tiny disc. Larger instruments or high-resolution planetary imaging setups may show atmospheric banding, especially through long-pass red filters. Rare, bright storms do occur in Uranus's atmosphere and if these are particularly large, they may be detected and recorded by amateur equipment.

Sitting on the threshold of naked-eye visibility at mag. +5.8, Uranus is best detected with a bit of optical assistance, such as that given by binoculars. However, through such a small instrument the planet simply appears like a sixth magnitude star.

A small telescope will reveal the planet's green hue, something that is quite striking if you've never seen it before.

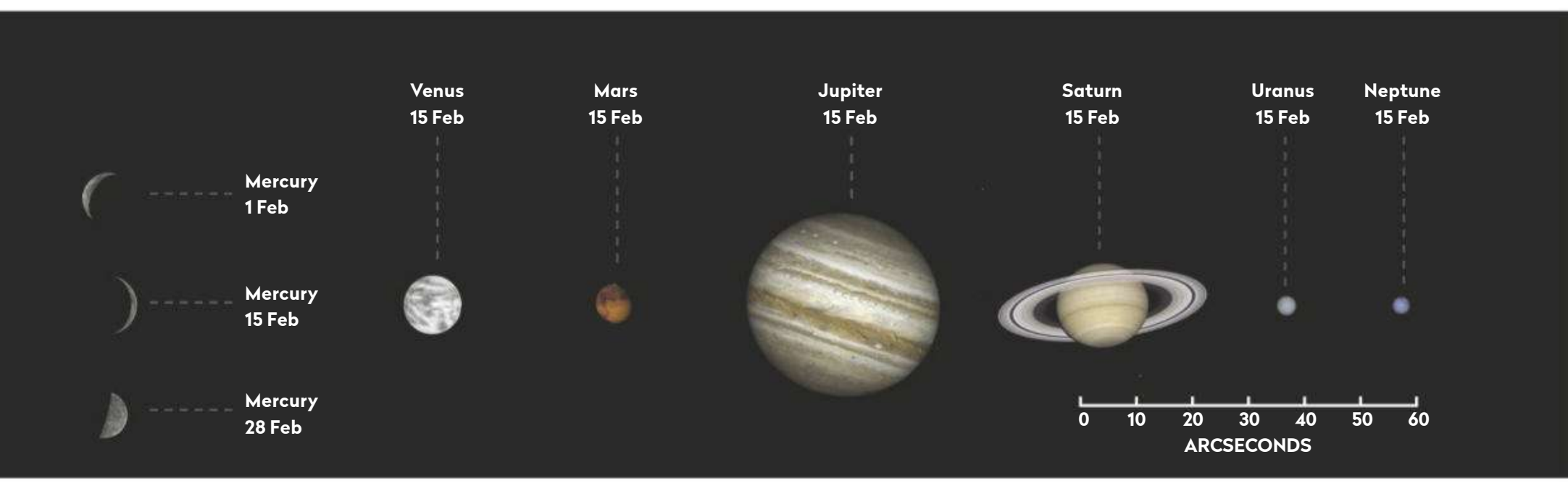
A 31%-lit Moon passes 3.2° south of Uranus on the evening of 17 February, presenting a good opportunity for catching both objects in the same photographic field of view with, say, a DSLR camera and a 300mm lens.

▲ **View Uranus through a small telescope to catch its green hue**

PETE LAWRENCE X 3

The planets in February

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 1 February, from 40 minutes after sunset
Altitude: 5° (low)
Location: Aquarius
Direction: West-southwest
Mercury is best seen at the month's start when it's visible in the evening sky, setting 70 minutes after the Sun on the 1st. At mag. +1.4, it's not very bright, which will hamper attempts to locate it. It then heads towards the Sun, probably becoming lost from view on the 5th, while inferior conjunction occurs on the 8th. After this Mercury emerges again into the morning sky, passing close to Jupiter and Saturn over February's last half.

Venus

Best time to see: 1 February, 20 minutes before sunrise
Altitude: 0.5° (extremely low)
Location: Sagittarius
Direction: Southeast
Mag. –3.9 Venus is a morning object, poorly positioned due to a shallow ecliptic angle. The time between Venus rising and sunrise reduces from 26 minutes at the start of February to zero at the month's end. Venus and Jupiter are 31 arcminutes apart on the 11th, which will be tricky to spot in the morning twilight as Venus rises just 12 minutes before the Sun.

Mars

Best time to see: 1 February, 18:30 UT
Altitude: 54°
Location: Aries
Direction: Just west of south
Mars fades this month, from mag. +0.4 on the 1st to +0.9 by its close. Through a scope the planet shows an 89% disc during February, its apparent size dipping from 7.9 to 6.4 arcseconds over the month. A 40%-lit waxing crescent Moon sits 5° from Mars on the evening of the 18th. By the end of the month, Mars will sit 3.3° south of the Pleiades.

Jupiter

Best time to see: 28 February, 20 minutes before sunrise
Altitude: 1.3° (very low)
Location: Capricornus
Direction: Southeast
Jupiter and Saturn re-emerge from solar conjunction into the morning sky this month, but are too close to the Sun to be seen properly. A close conjunction between Jupiter and Venus occurs on the morning of the 11th, with both planets being half a degree apart. They will be difficult to see though, rising 10 minutes before the Sun. By the 28th, Jupiter and Saturn are on view above a flat southeast horizon shortly before sunrise.

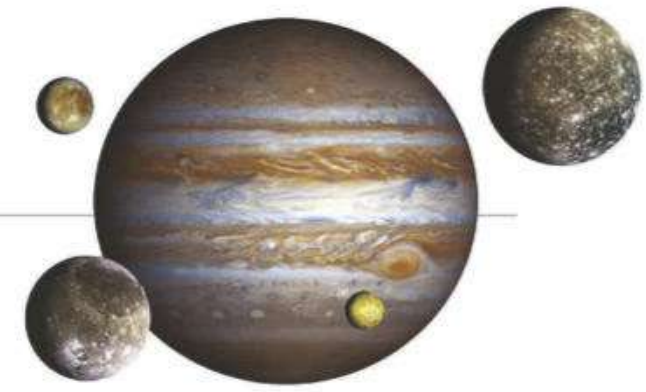
Saturn

Best time to see: 28 February, 30 minutes before sunrise
Altitude: 2° (very low)
Location: Capricornus
Direction: Southeast
Saturn was in conjunction with the Sun on 24 January and now appears in the morning sky. It's poorly positioned all month. The best chance of spotting it will be on the 28th, when it rises one hour before the Sun.

Neptune

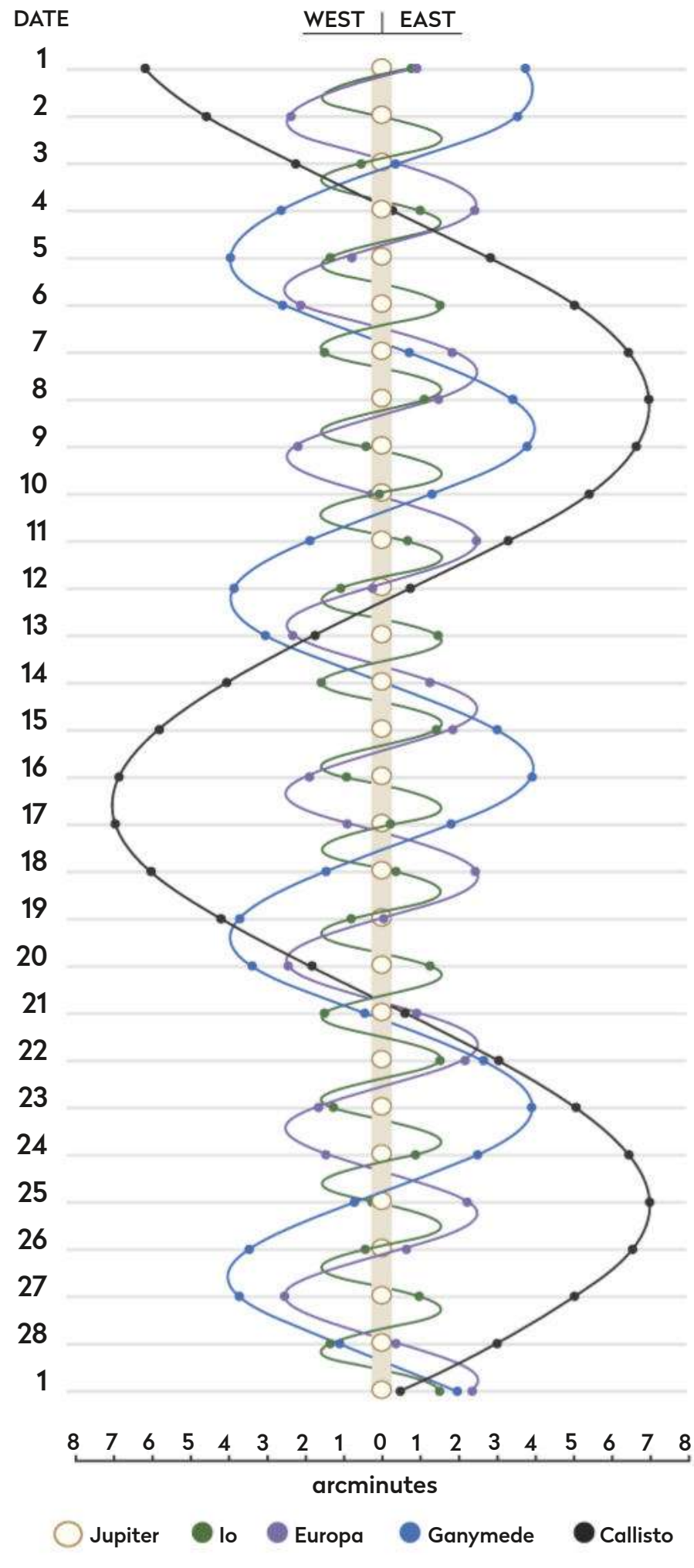
Best time to see: 1 February, 19:00 UT
Altitude: 11°
Location: Aquarius
Direction: West-southwest
Neptune is a compromised evening planet, only achieving 11° altitude above the west-southwest horizon on the 1st under truly dark conditions. It requires binoculars to see, shining at mag. +8.0. By the month's end, it will be lost to the evening twilight glow.

More **ONLINE**
Print out observing forms for recording planetary events



JUPITER'S MOONS: FEBRUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – FEBRUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- ASTERISM (Circlet)
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW (5°, N, E, W, S)
- MILKY WAY

When to use this chart

1 February at 00:00 UT
15 February at 23:00 UT
28 February at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in February*

Date	Sunrise	Sunset
1 Feb 2021	07:55 UT	16:53 UT
11 Feb 2021	07:36 UT	17:13 UT
21 Feb 2021	07:15 UT	17:33 UT
03 Mar 2021	06:53 UT	17:52 UT

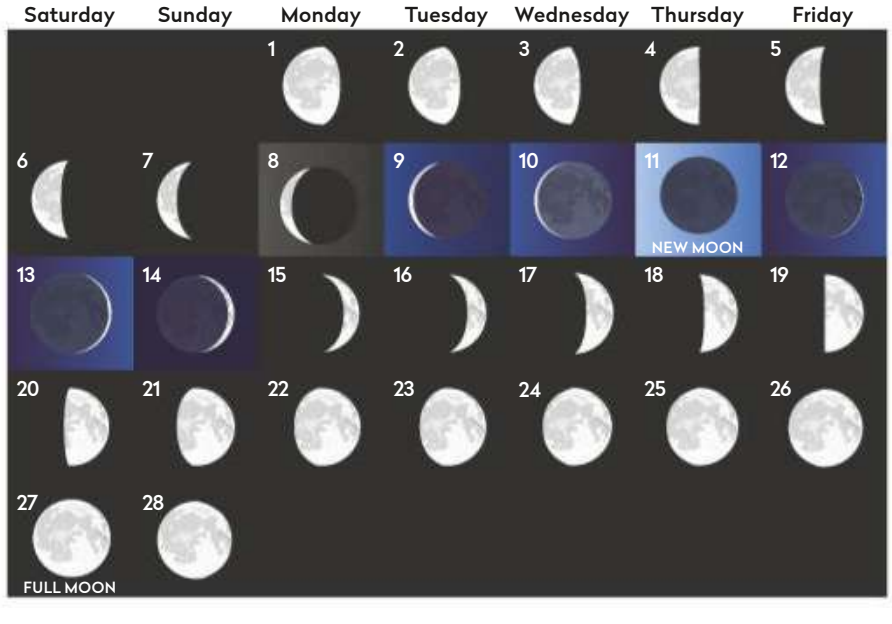
Moonrise in February*

Moonrise times

1 Feb 2021, 21:41 UT	17 Feb 2021, 09:38 UT
5 Feb 2021, 01:56 UT	21 Feb 2021, 11:03 UT
9 Feb 2021, 06:52 UT	25 Feb 2021, 15:02 UT
13 Feb 2021, 08:45 UT	01 Mar 2021, 20:47 UT

*Times correct for the centre of the UK

Lunar phases in February



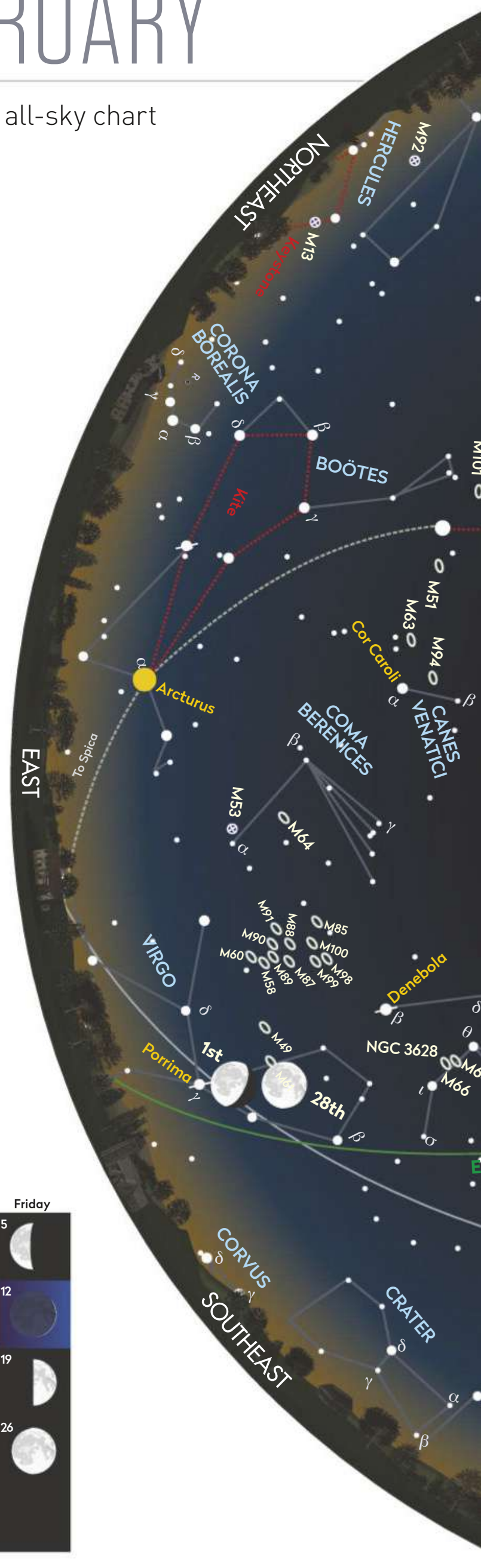


CHART: PETE LAWRENCE

MORE **ONLINE**

Paul and Pete's night-sky highlights

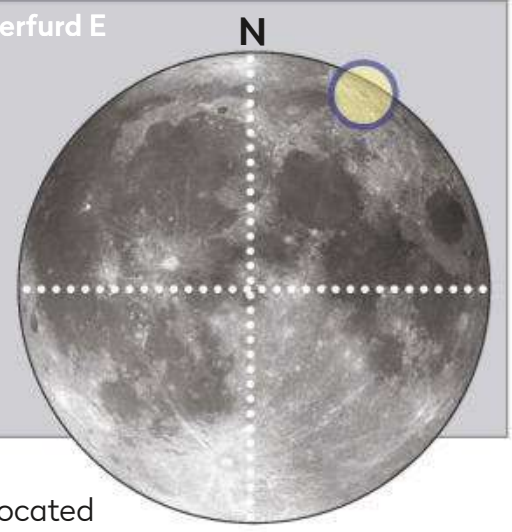
Southern Hemisphere sky guide

MOONWATCH

February's top lunar feature to observe

Endymion

Type: Crater
Size: 126km
Longitude/Latitude: 56.5° E, 53.6° N
Age: Older than 3.9 billion years
Best time to see: Three days after new Moon (14–15 Feb) and two days after full Moon (30 Jan & 28 Feb)
Minimum equipment: 10x binoculars



Endymion is an impressive walled plain located close to the Moon's northeast limb. As a consequence, the crater appears foreshortened from Earth and is subject to the effects of libration – a rocking and rolling action stemming from the fact that the Moon's orbit is tilted and elliptical. A favourable libration will bring Endymion closer to the Moon's centre and as it does so, 260km Mare Humboldtianum also rotates into view, visible between Endymion and the Moon's limb. When the libration is unfavourable and Endymion is close to the lunar limb, it may appear separated from the limb by an amount equal to the crater's narrowest apparent dimension. At a favourable libration, Endymion's eastern rim appears separated from the Moon's limb by 2.5x the crater's longest apparent dimension – a notable variation. In late January and early February, libration is unfavourable, but it's favourable mid-month, giving you the best of both worlds.

PETE LAWRENCE X

Endymion is best viewed during early lunar phases or after full Moon

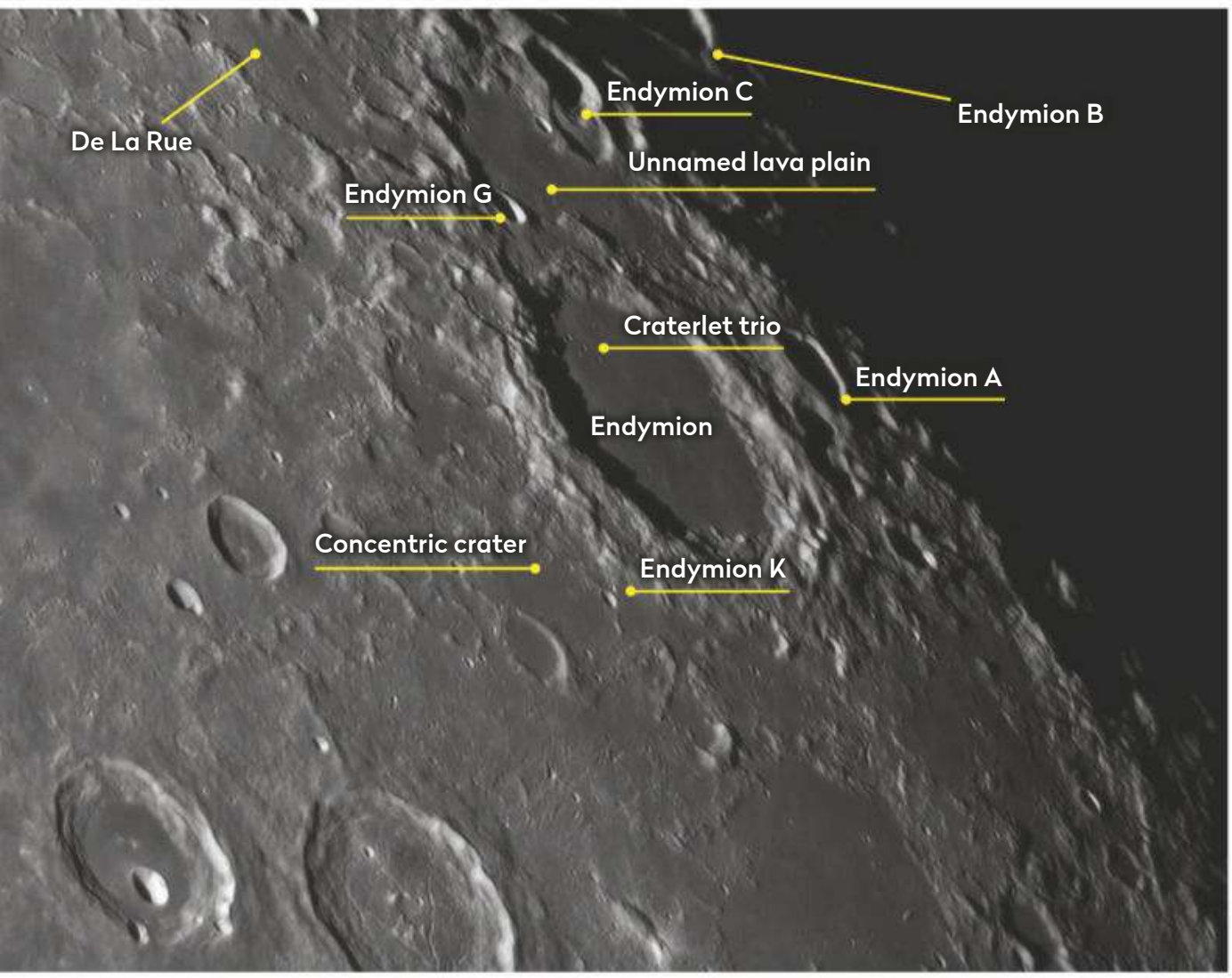
Endymion is 4km deep with isolated peaks on the eastern rim rising as high as 4.6km. Its location means that the crater is best viewed during the early lunar phases or after full Moon. As ever, most detail appears when sunlight hits the crater obliquely. Endymion's rim consists of a series of complex terraces leading down to a smooth, virtually featureless floor. With care, it's possible to see variation in the tonal appearance of this floor; lighter streaks running north to south are the most obvious features here.

The completely smooth appearance of Endymion's floor is broken at high resolution. There's a curious line of three craterlets towards the north of the crater, the northernmost two being 3km in diameter, the southern one slightly smaller at 2.7km. A further depression sits west of the middle craterlet but this isn't as deep as the main trio. These features stand as a good test for a 200mm instrument or high-resolution imaging setup.

If you fancy another observing challenge, there's an interesting **unnamed ancient crater**, 121km southwest of Endymion's centre. To locate it, use the narrow dimension of the crater as a ruler and imagine where the western rim would appear if you slid the crater towards the Moon's centre, so that the eastern rim would end up where the current crater's centre lies. If you can follow this admittedly convoluted description, the displaced western rim overlays the unnamed feature, a 6.5km shallow crater with a perfectly aligned inner ring that's 2.8km in diameter. This unusual concentric crater lies 26.5km to the northwest of 7km **Endymion K**.

Located immediately east of Endymion is **Endymion A**, a well-defined 30km-crater itself, showing lots of internal structure. The same can be said of 60km **Endymion B** although this feature lies a fair distance further to the northeast, 182km centre-to-centre from Endymion A.

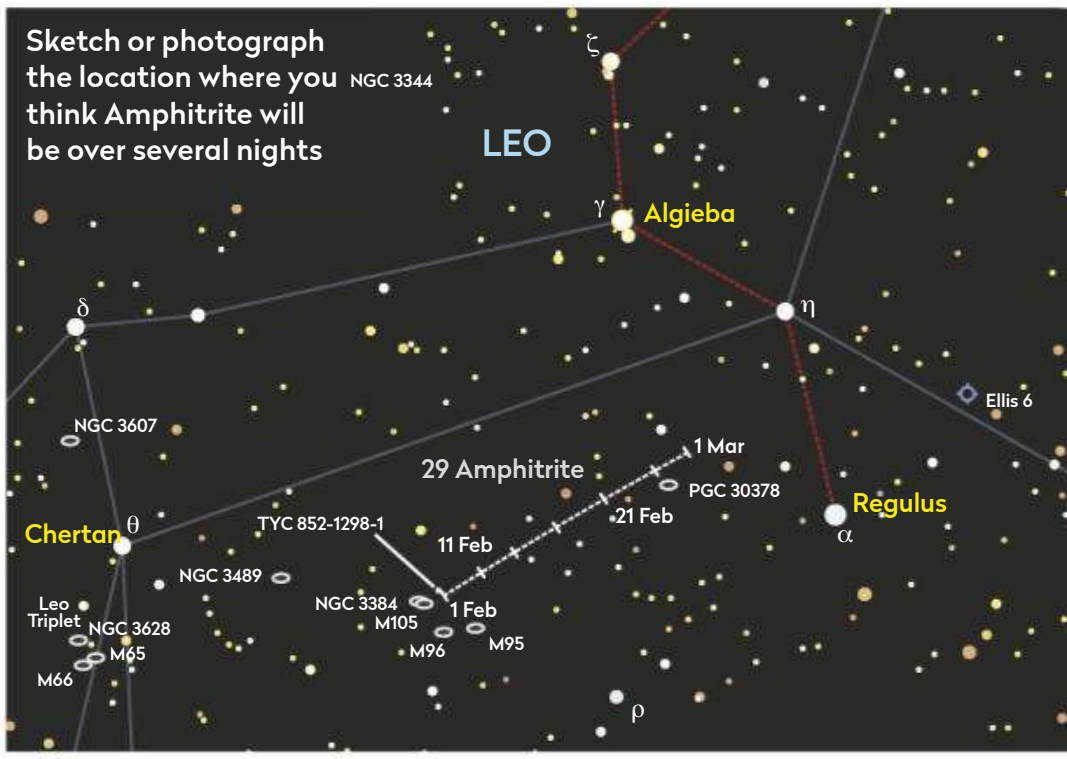
North of Endymion is 136km **De La Rue**, an ancient and rather battered feature. Between the pair lies 15km **Endymion G**. This small crater sits on the western edge of a large unnamed lava plain. The northern, western and eastern borders of this plain appear like a rough crater rim, leading to the speculation that this is actually a highly eroded ancient crater.



▼ **Crater Endymion is located on the Moon's northeastern limb**

COMETS AND ASTEROIDS

Spot asteroid 29 Amphitrite as it reaches opposition in the constellation of Leo



Minor planet 29 Amphitrite reaches opposition on 22 February, when it can be found shining among the stars of Leo, the Lion at mag. +9.1. At 00:00 UT on the 1st, it can be found south of mag. +6.9 TYC 852-1298-1, about a degree north-northeast of the mag. +9.5 elliptical galaxy M105 near the Lion's belly.

At February's start Amphitrite will be at mag. +9.6, its dimmest for the month. It brightens to mag. +9.1 by the 20th, remaining at this level until the 24th, before dimming back to mag. +9.2 by month end. Its track takes it into the body of Leo to end 4° northwest of Regulus (Alpha (α) Leonis) on the 28th.

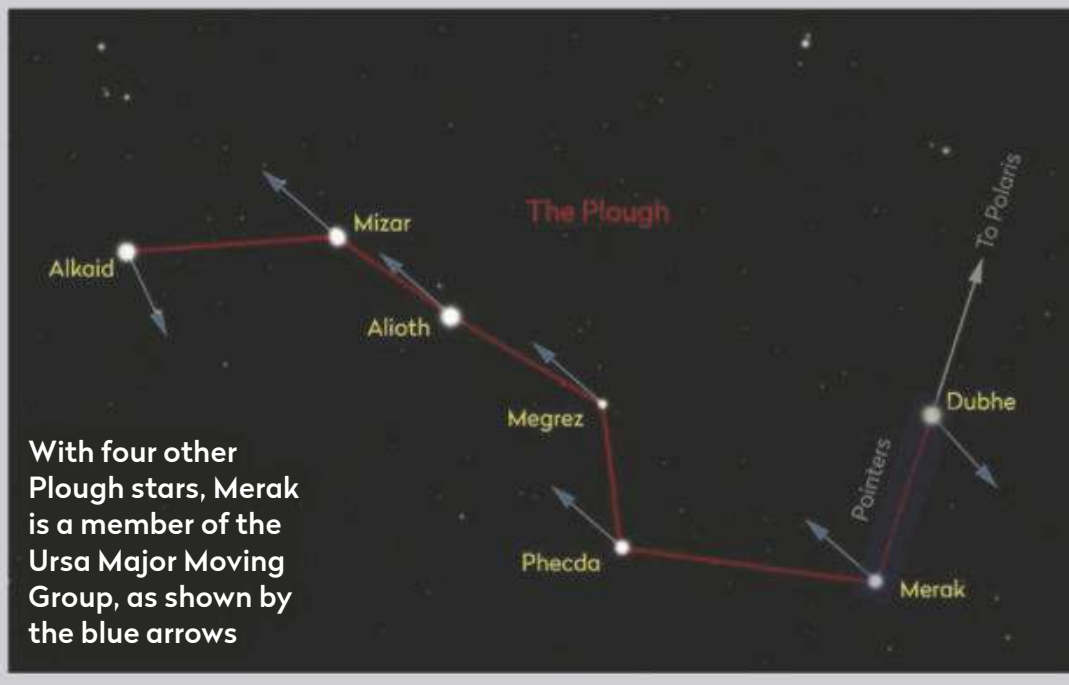
Amphitrite is one of the largest S-type asteroids known, with a diameter around 200km; S-type asteroids are stony in composition (siliceous mineralogical). Approximately 17 per cent of all the known asteroids are S-type. At favourable oppositions Amphitrite can reach mag. +8.6, but normally it hovers around mag. +9.5, the threshold brightness for average binoculars.

Amphitrite's small magnitude range comes from its fairly circular orbit; a more eccentric orbit typically produces a more pronounced variation between brightest and dimmest magnitudes. Its orbital distance from the Sun varies from 2.7 AU (410 million km) at aphelion to 2.37 AU (355 million km) at perihelion. Amphitrite takes 4.09 years to complete each orbit, rotating once on its own axis every 5.4 hours.

The Moon will be in its fuller phases towards February's start and end, but this shouldn't stop you from seeing Amphitrite as the asteroid appears as a point source of light.

STAR OF THE MONTH

Spot Merak, at the bottom of the Plough



With four other Plough stars, Merak is a member of the Ursa Major Moving Group, as shown by the blue arrows

Merak (Beta (β) Ursae Majoris) is the southernmost of the two stars in the Plough asterism which form the navigational pair known as 'The Pointers'. They get this label because they literally point at the Pole Star, Polaris (Alpha (α) Ursae Minoris). The name Merak means 'the loins of the bear' and despite its prominent position and beta designation it is actually the fifth brightest of the seven stars that form the familiar Plough pattern. Merak shines at mag. +2.4. The Plough is circumpolar from the UK – close enough to Polaris to never be able to set below the horizon. Consequently, it and Merak are always visible to the naked eye from the UK whenever the sky is dark and clear.

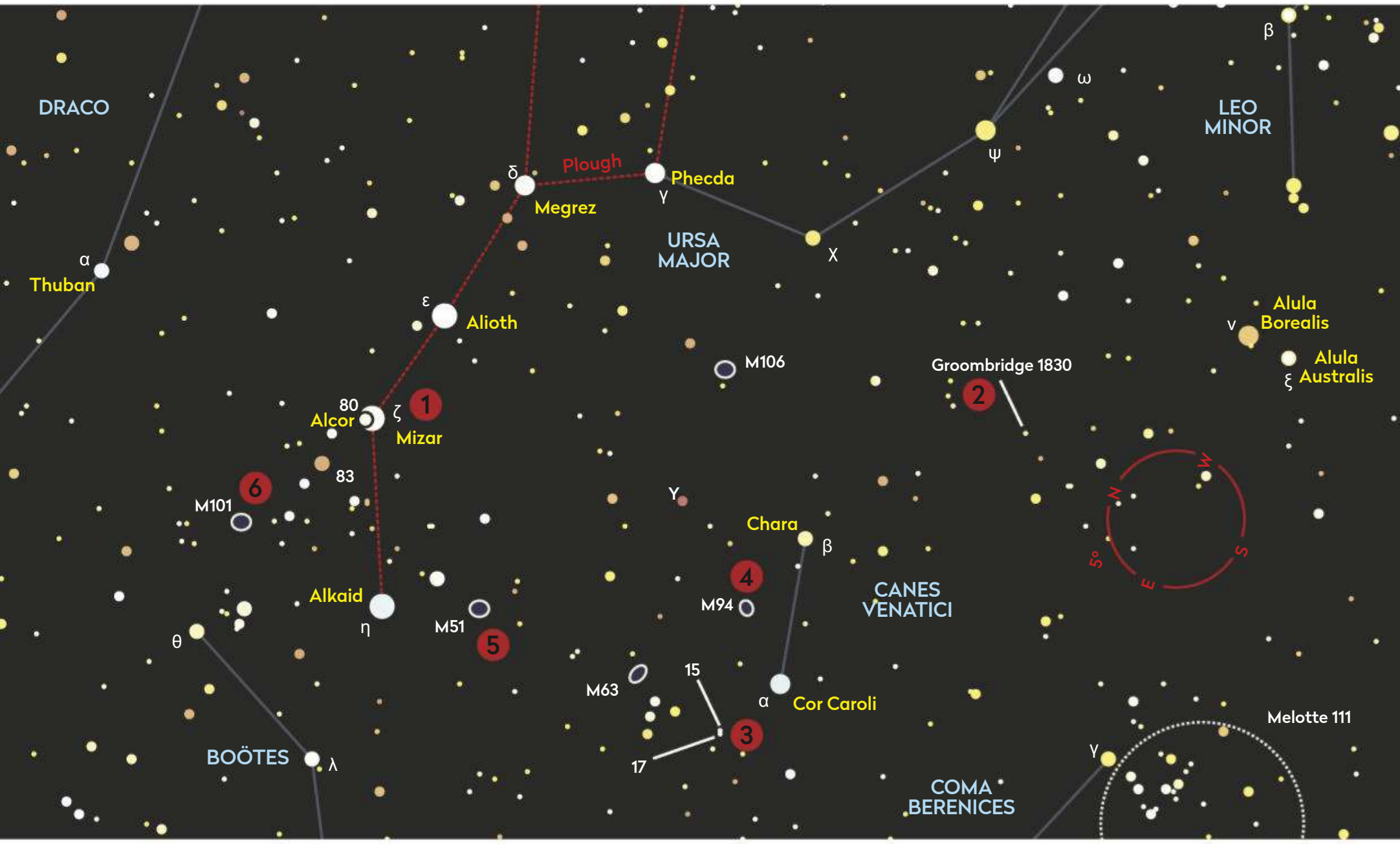
Merak is a white sub-giant star of spectral classification A1 IV. It also shows unusually strong lines of certain metals in its spectrum; 'metals' in astronomy refers to elements heavier than hydrogen. The distance to Merak has been measured as 79.7 lightyears and it is one of five stars in the Plough asterism that belong to an association known as the Ursa Major Moving Group. This group of five – all but Dubhe (Alpha (α) Ursae Majoris) and Alkaid (Eta (ε) Ursae Majoris) – have matching proper motions; a term that describes the direction and speed of movement of a star in space. This indicates a probability that they are related, a group of stars along with others in the association, which would have formed together.

Merak is three times larger than the Sun, has a mass 2.7 times larger and a luminosity 63 times higher. It also has an infrared excess – indicating that it is likely to have a circumstellar disc surrounding it, which probably comprises orbiting dust.

BINOCULAR TOUR

With Steve Tonkin

This month we explore the region around Mizor and Alcor in the Plough's handle



1. Mizar and Alcor

10x 50 Mizar (Zeta (ζ) Ursae Majoris) and Alcor (80 Ursae Majoris), were once used as an eyesight test: if you couldn't see two stars, you needed spectacles. They are easy to split in binoculars, and these also reveal a fainter (mag. +7.6) companion that makes the southeast apex of a triangle with Alcor and Mizar. Extend a line from Mizar through this companion for 2.5° to find the red 83 Ursae Majoris. ☐ **SEEN IT**

2. Groombridge 1830

10x 50 Groombridge 1830 has the third greatest proper motion (the apparent motion of a star relative to the celestial sphere) and it is brighter (mag. +6.5) and easier to find than the faster two. It is half way between Chara (Beta (β) Canum Venaticorum) and Alula Borealis (Nu (ν) Ursae Majoris). This will take a few years, but if you plot its position in relation to its surrounding stars, you should notice its changing position. ☐ **SEEN IT**

3. 15 & 17 CVn

10x 50 Navigate a little more than 2.5° east from Cor Caroli (Alpha (α) Canum Venaticorum), where you will find a widely separated (4.6 arcminutes) pair of stars, 15 CVn and 17 CVn. This is not a binary star, but merely a line-of-sight pairing that shows how distance affects magnitude: although they appear to us to be of similar brightness, 15 CVn is six times as far and 25 times as bright as 17 CVn. ☐ **SEEN IT**

4. M94

15x 70 Return to Cor Caroli and imagine a line between it and Chara. From half way along this line, navigate 2° in the direction of Alkaid (Eta (η) Ursae Majoris). Here, possibly needing averted vision at first, you should find the faint glow of light from the spiral galaxy M94. Like all galaxies it benefits greatly from dark, transparent skies, but it is usually quite easy to detect once it is above any low-level sky-glow. ☐ **SEEN IT**

5. M51

15x 70 Our next galaxy is brighter and is easy to find. Imagine that a line from Mizar to Alkaid is the upright of a letter 'L'; M51 lies at the 'toe' of this imaginary 'L', 3.5° from Alkaid in the direction of M94. You'll see the glow of 25 billion suns that lie 20 million lightyears away. If you use averted vision, can you detect that it is slightly elongated? ☐ **SEEN IT**

6. M101

10x 50 Because M101 is a large, faint galaxy, we don't want to magnify it too much and, to maximise our chance of seeing it, we'll wait for pristine sky conditions when the galaxy is above any skyglow. Picture an equilateral triangle with Mizar and Alkaid as its base; M101 is just inside the third apex. With averted vision, you should notice a ghostly patch that is a bit brighter than the rest of the sky. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 2

THE SKY GUIDE CHALLENGE

Can you spot Mare Humboldtianum and watch as the sea librates out of view

This month's 'Moonwatch' target on page 52 is the crater Endymion. From Earth, this 126km diameter feature appears located close to the Moon's northeast limb. This month we're challenging you to locate Mare Humboldtianum, a sea near to Endymion in the zone of libration. Your challenge is to first identify the sea and then watch it as libration rotates it out of view.

The Moon's orbit is elliptical and tilted to the plane of Earth's. Although the Moon is gravitationally locked to Earth so that one face always points towards us, the tilt of its orbit and its elliptical shape causes a rocking and rolling action to be seen from Earth. This combined movement is known as libration.

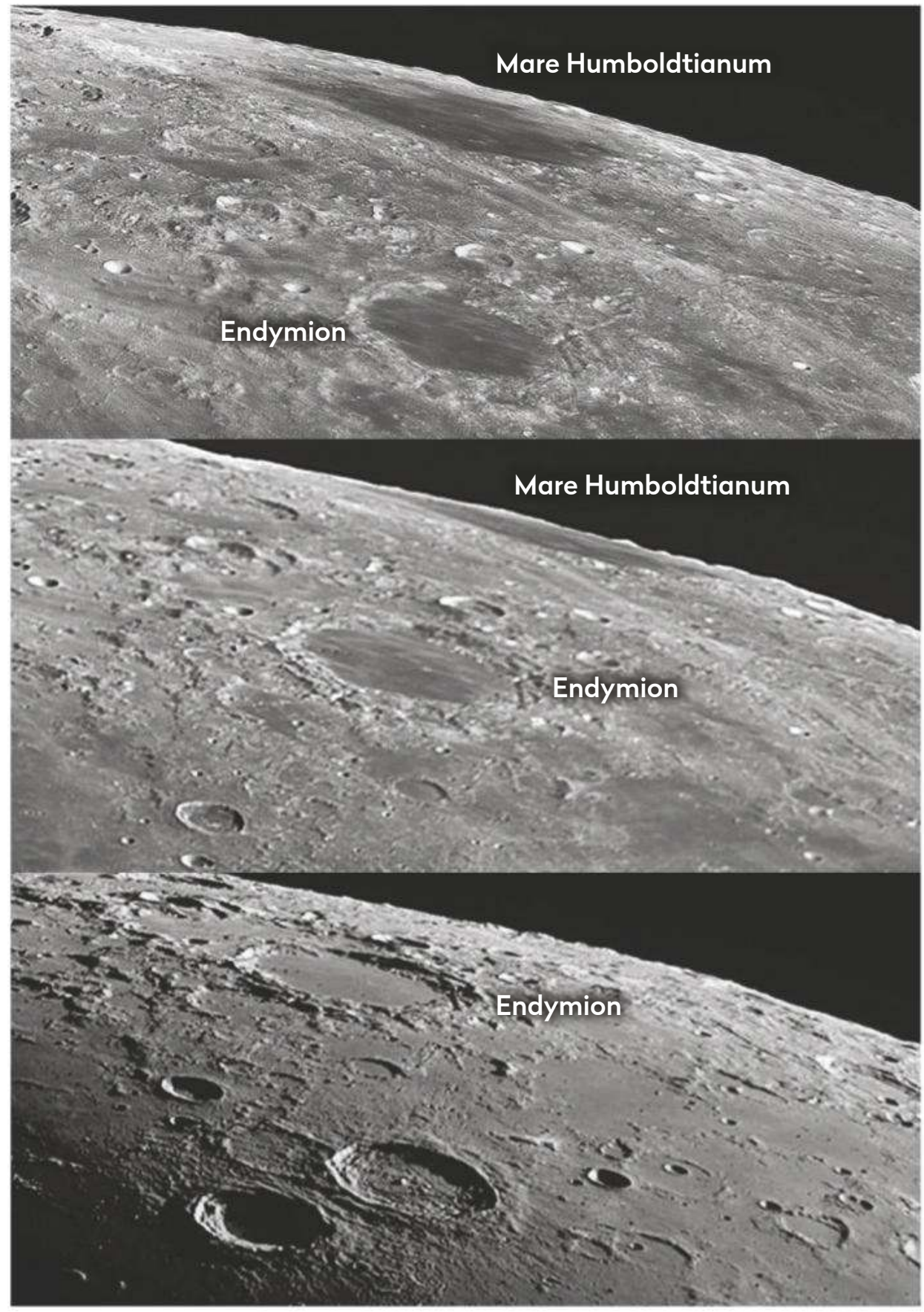
Features near to the Moon's limb as seen from Earth appear to approach and distance themselves from their nearest limb over the course of a lunar month. If sped up the motion would appear quite hypnotic, an oscillating action tantalisingly bringing features into good view before snatching them away once again. Endymion does this. When closest to the limb it appears like a narrow ellipse, heavily foreshortened. When farthest from the limb, it still appears foreshortened but the ellipse of its rim is wider, allowing you to better see internal detail. However, despite its variable appearance, Endymion always remains visible from Earth, irrespective of the Moon's overall libration state.

This is not the case for Mare Humboldtianum located northeast of Endymion. This 160km x 160km lava sea has the advantage of being visible when the Sun is high in its sky. Consequently, it is possible to follow it for a decent amount of time whenever it's lit by the Sun and libration keeps it in view.

It will probably first become visible on the evening of 13 February when the Moon is at a 4 per cent phase. With the terminator virtually touching the mare's western edge during the early evening of 13 February, it may be difficult to identify it precisely. Visibility improves over subsequent evenings allowing you to spot Humboldtianum even as libration takes it closer towards, then over, the Moon's limb. On the evening of the 22nd, Mare Humboldtianum is right on the edge of the 78%-lit waxing gibbous Moon. By the 26th, just before full Moon on the 27th, Humboldtianum will have disappeared from view, dragged over the Moon's edge by libration.

See if you can watch this happen from one night to the next. If you're an astrophotographer, why not try and take a sequence of images which can then be animated to show how the sea disappears. If you can, use a bit of magnification for this, using Endymion as a positional anchor. If the clouds get in the way, another opportunity occurs next month between 15–27 March.

Follow Mare Humboldtianum when it's lit by the Sun



▲ **Mare Humboldtianum approaching, then disappearing, over the Moon's limb**

DEEP-SKY TOUR

We explore the open clusters in the constellation of Auriga, the Charioteer

1 M38

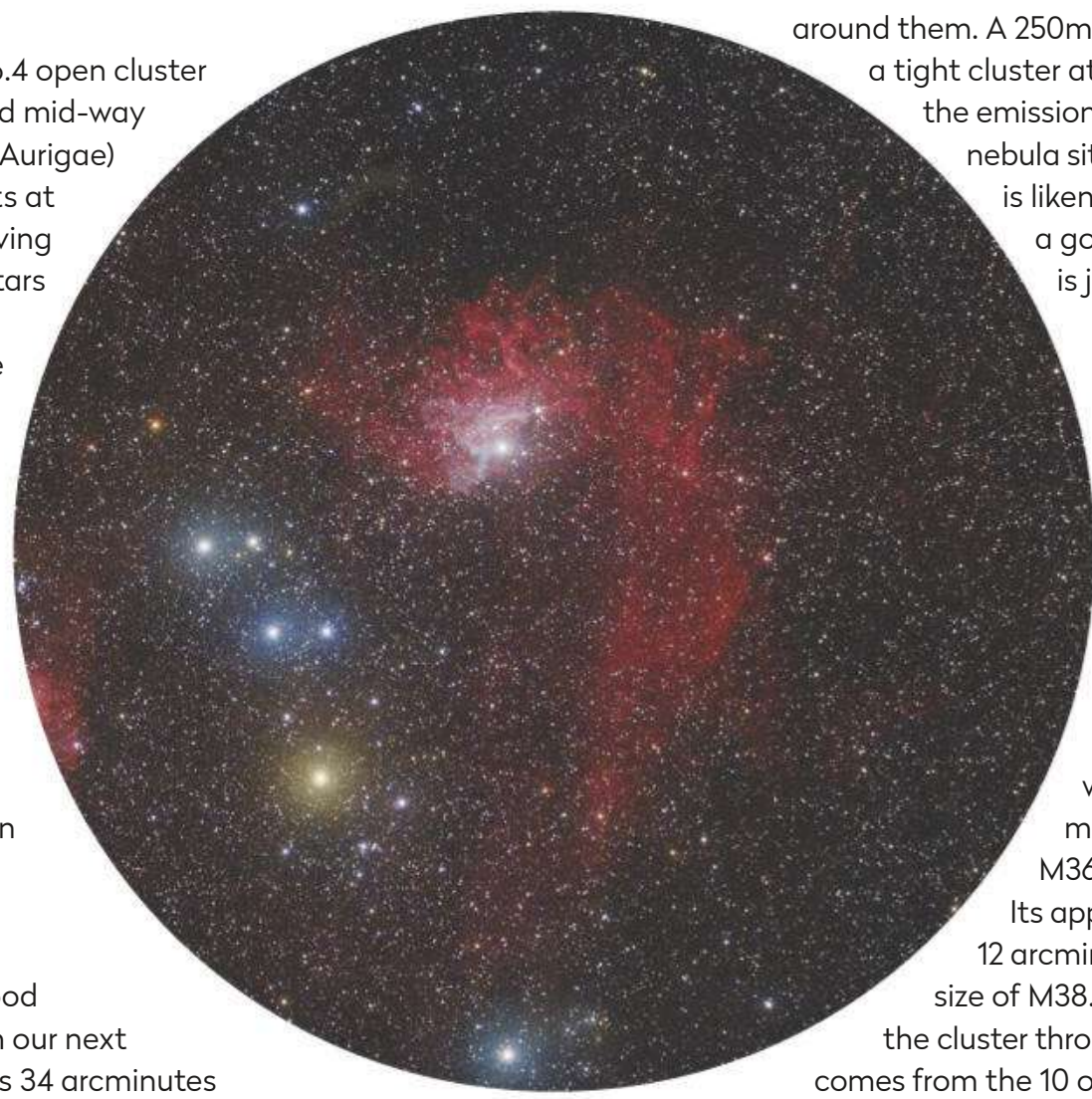
M38 is a mag. +6.4 open cluster in Auriga, located mid-way between Hassaleh (Iota (ι) Aurigae) and Theta (θ) Aurigae. It sits at the northeast end of a curving line of mag. +6.0 and +7.0 stars that forms the smile of the Cheshire Cat asterism. The cluster is rich with a good distribution of bright and dim members. Through a 150mm scope some of the brighter stars appear to form a cross or, with a bit of imagination, a shape that resembles a starfish. A 250mm instrument reveals around 100–150 members within an area 20 arcminutes across.

2 NGC 1907

M38 makes a good comparison with our next target, NGC 1907, which sits 34 arcminutes south and a bit west of M38. This is an old cluster with an estimated age of 500 million years. M38 by comparison is estimated to be half that age at 250 million years. NGC 1907 is also further away at 4,500 lightyears. Shining with an integrated magnitude of +8.2, NGC 1907 is compact, appearing one-sixth the size of M38. Around 30 stars can be seen with a 150mm scope, increasing to 40 when you double the aperture. The cluster is framed by a triangle of mag. +6.2, +6.8 and +6.9 stars. Analysis of M38 and NGC 1907 suggests both were formed in different regions of the galaxy and are experiencing a celestial 'fly-by'.

3 NGC 1931

Head back to M38 and then 100 arcminutes south-southeast for diffuse nebula NGC 1931. This object has emission and reflection regions, revealed by long exposure photography as an attractive composition of reds, pinks and blue-grey colours. It shines with an integrated magnitude of +11.3 and although visible through smaller instruments, benefits from extra light grasp. Through a 150mm scope, the most obvious feature is a tight group of three stars. Under dark-sky conditions a glow is visible around them. A 250mm scope shows four stars in a tight cluster at the glow's centre. This is the emission component, the reflection nebula sitting to the south. NGC 1931 is likened to a small Orion Nebula, a good description as NGC 1931 is just 3 arcminutes across.



FRANZ KLAUSER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

▲ IC 405, the Flaming Star Nebula is faint to observe but it really shines with long exposure photography

4 M36

M36 is one of the famous Auriga trio of Messier open clusters, along with M37 and M38. It lies 2.3° southeast of M38 or, from our last target, 1° to the east of NGC 1931. It's a lovely cluster that shines with an integrated magnitude of +6.0. Visually, M36 appears smaller than M38. Its apparent diameter is around 12 arcminutes, so almost half the size of M38. The main impression from the cluster through smaller instruments comes from the 10 or so members that shine brighter than mag. +10.0. A 300mm scope reveals as many as 70 members within this cluster.

5 IC 405

Before visiting the final Messier cluster in the Auriga trio, deviate west to dim IC 405; the Flaming Star Nebula. This sits 4.1° west of M36 and requires a larger aperture, dark skies and a hydrogen-beta filter to see properly. Actually, let's not mislead here, because given a good dark sky, it is possible to see IC 405 using a hydrogen-beta filter through apertures as small as 100mm. It surrounds irregular variable AE Aurigae, which shines at mag. +6.0 and deviates between mag. +5.8 and +6.1. AE Aurigae is a runaway star that's likely to have been ejected from the Trapezium Cluster at the Orion Nebula's heart.

6 M37

We leave the faintness of IC 405 to view the final member of the Auriga Messier trio, M37. This sits 3.8° southeast of M36 and at mag. +5.6 is the trio's brightest. It's also the richest; a visual delight through any instrument size. It's about 20 arcminutes across and well concentrated. Smaller instruments may show it as a partly resolved haze of stars. A 250mm or larger scope is required to resolve it fully. The compact nature of the cluster's core region can make it tricky to identify all of the member stars. M37 is located near the intersection of the Galactic Equator and Galactic Meridian, placing it almost opposite the direction of the Milky Way's core as seen from Earth.

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

AURIGA

TAURUS

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Elnath
Hassaleh

Collinder 62
NGC 1857
NGC 1907
M38
NGC 1931
NGC 1893
IC 405
NGC 1778
M37
M36
Basel 4
Kohoutek 2-1

1
2
3
4
5
6

Cheshire Cat

+40°
+35°
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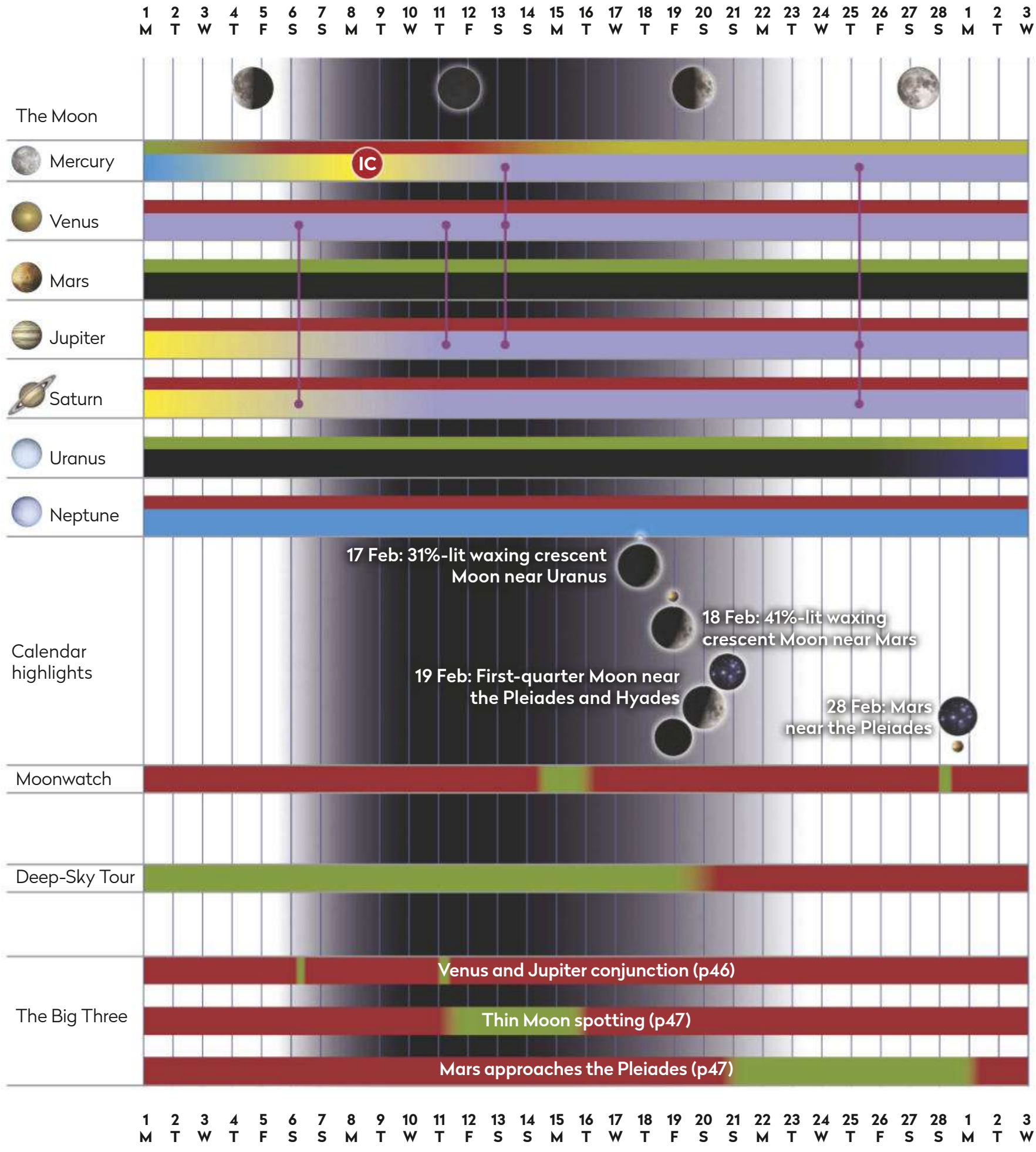
AT A GLANCE

How the Sky Guide events will appear in February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The Moon
Mercury
IC
Venus
Mars
Jupiter
Saturn
Uranus
Neptune
Calendar highlights
17 Feb: 31%-lit waxing crescent Moon near Uranus
18 Feb: 41%-lit waxing crescent Moon near Mars
19 Feb: First-quarter Moon near the Pleiades and Hyades
28 Feb: Mars near the Pleiades
Moonwatch
Deep-Sky Tour
The Big Three
Venus and Jupiter conjunction (p46)
Thin Moon spotting (p47)
Mars approaches the Pleiades (p47)
1 M 2 T 3 W 4 T 5 F 6 S 7 S 8 M 9 T 10 W 11 T 12 F 13 S 14 S 15 M 16 T 17 W 18 T 19 F 20 S 21 S 22 M 23 T 24 W 25 T 26 F 27 S 28 S 1 M 2 T 3 W

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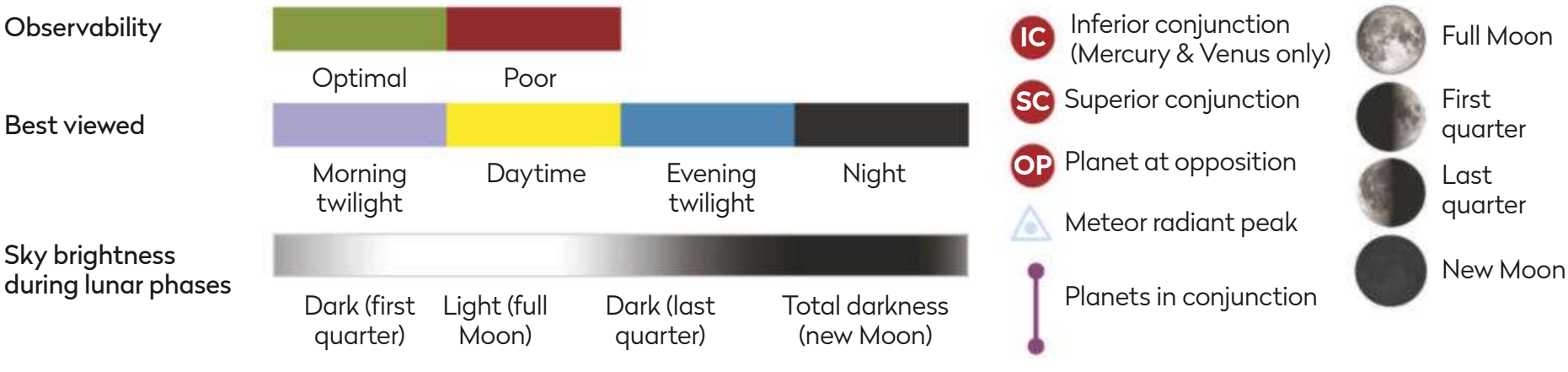

CHART BY PETE LAWRENCE

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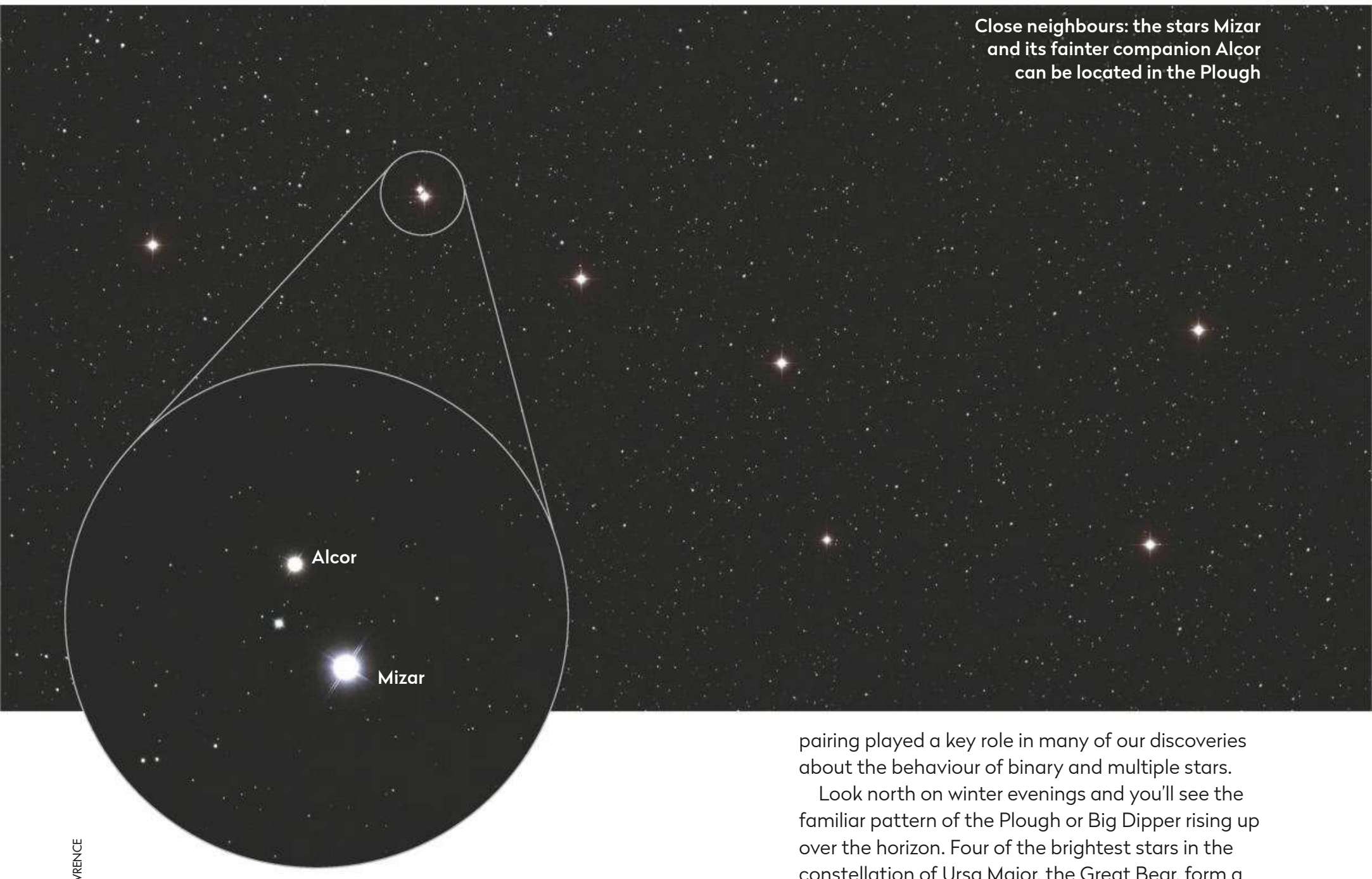
The fundamentals of astronomy for beginners

EXPLAINER

Amazing stars: Mizar and Alcor

Giles Sparrow reveals the secrets of this intriguing stellar system in the Plough asterism



Close neighbours: the stars Mizar and its fainter companion Alcor can be located in the Plough

CHRISTOPHE LEHENAFF/ISTOCK/GETTY IMAGES X 2, PETE LAWRENCE

Stars, like bobbies on the beat, have a tendency to come in pairs. Born in large clusters from collapsing clouds of interstellar gas, they're gregarious by nature, and many emerge from the turbulent breakup of their birth cluster still locked in orbit with one or more companions. Most of these stellar pairings are too closely bound (or too far away) to be seen with even a powerful telescope, but one particular pair is easy to spot with the naked eye alone. What's more, this famous stellar pairing played a key role in many of our discoveries about the behaviour of binary and multiple stars.

Look north on winter evenings and you'll see the familiar pattern of the Plough or Big Dipper rising up over the horizon. Four of the brightest stars in the constellation of Ursa Major, the Great Bear, form a distinctive 'bowl' or 'blade', while three more make a curving handle. Even a casual glance at Mizar (Zeta (ζ) Ursae Majoris), the middle star of this handle, should reveal something unusual about it – a fainter companion, Alcor (80 Ursae Majoris), separated by about one-third the width of a full Moon.

Such a close pairing might seem to immediately mark the two stars out as a genuine binary star (a pair bound together by gravity in orbit around each other), but the link remained unproven for a long time. It wasn't until 1869 that Richard Anthony Proctor discovered that both stars are moving in the same

◄ **Closer inspection still reveals that Mizar itself is a binary made of Mizar A and Mizar B**

direction across the sky, as members of the 'Ursa Major Moving Group' (a scattered system of stars that marks the remains of a nearby disintegrating star cluster). We now know that they are both about 82 lightyears from Earth and are bound by gravity in a loose, million-year orbit.

Not pure coincidence

Take a look at Mizar itself through binoculars and depending on your eyesight it'll either look slightly blurry, or you may see that it's actually split into two stars of differing brightness, Mizar A and B. A small telescope should show them easily. Mizar's binary nature was first spotted by Italian monk Benedetto Castelli around 1617, and from the 1650s it became a firm favourite for observers. Countless other tight stellar pairings were found across the sky as telescopes improved. But it wasn't until 1802 that William Herschel argued there were too many double stars in the sky to be merely a chance – some must be gravitationally bound pairs, which he called 'binary stars'.

Giles Sparrow is an astronomy writer. His recent book, *A History of the Universe in 21 Stars*, is published by Welbeck

Herschel proved his case by showing that another stellar pair in Ursa Major, known as Alula Australis (Xi (ξ) Ursae Majoris), was shifting their relative positions in the sky as they orbited each other. He attempted similar measurements for Mizar, but found that its stars moved too slowly due to their wide separation (today we know that they take about 5,000 years to orbit each other).

By the 1890s, however, Mizar revealed a further secret when astronomers captured the spectra of its two stars – the rainbow-like bands produced when their light is split according to colour and wavelength. Dark lines in the spectrum of Mizar A – caused by calcium in the star's atmosphere absorbing specific wavelengths of light – appeared fuzzier than in other stars, and periodically split apart into separate lines.

This strange behaviour revealed that Mizar A is itself a binary star, with two components that are inseparable through even the most powerful telescope. The fuzziness and splitting of the spectral lines is caused by the Doppler effect – the compression or stretching of light waves (and slight accompanying shifts in their colour) when stars move towards or away from Earth. When one star is moving at its fastest towards us and the other away, these shifts are at their greatest, while at other times in their 20.5-day orbit, the effect is unnoticeable.

As the first 'spectroscopic binary' to be discovered, Mizar A paved the way for a huge range of new techniques that allowed astronomers to calculate the mass and other physical properties of stars in the early 20th century – just one of many ways in which this remarkable stellar double act has contributed to our understanding of how stars live and evolve.

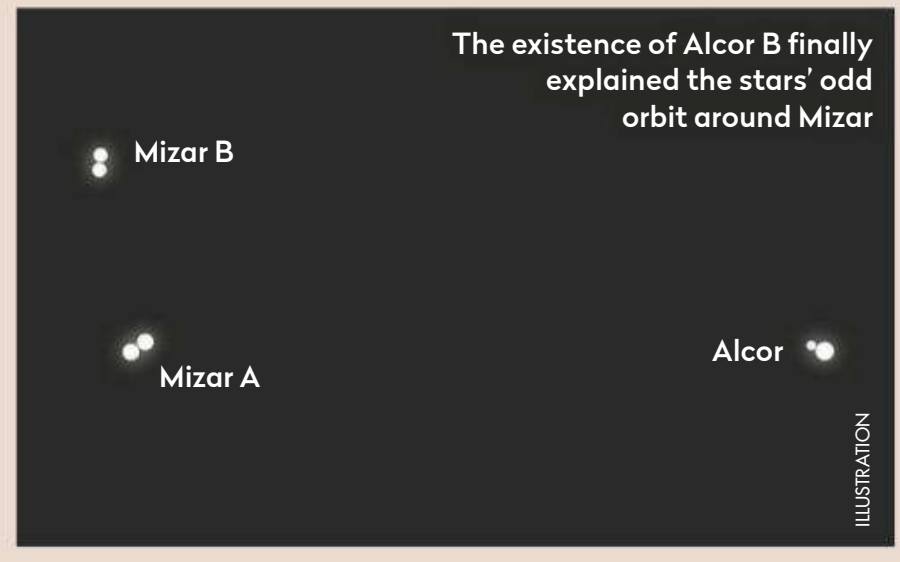
Stellar sextuplets

The mystery of the 'wandering' star revealed

The discovery of Mizar A's binary nature made Mizar (considered alone) the first triple star system of this kind to be discovered – and in 1908 it became the first quadruple star when astronomers Edwin B Frost and Hans Ludendorff discovered that Mizar B is a spectroscopic binary in its own right. In the mid-20th century, astronomers also suspected that Alcor might be a spectroscopic double, although this idea was disproved in 1965.

However, in 2009, another twist in the tale came courtesy of Clio, an infrared planet-hunting instrument at the University of Arizona's MMT observatory. Ignoring the bright visible light pumped out by Alcor's hot white surface, it zeroed in on a faint infrared signature and confirmed the presence of a tiny red dwarf star orbiting Alcor.

The discovery of 'Alcor B' also finally settled lingering doubts about the relationship between Mizar and Alcor, explaining why Alcor occasionally deviated from the path predicted for its orbit around Mizar. A family of scattered stellar sextuplets was finally reunited.



The existence of Alcor B finally explained the stars' odd orbit around Mizar

The Red Planet's SKY AT NIGHT

This February, three missions will arrive at Mars. While their gaze will be on the planet, they will also see the Martian starscape above. **Stuart Atkinson** imagines the view they, and possible future human stargazers, will be treated to

At the beginning of the third *Star Trek* film the USS Enterprise, battered and bruised after defeating Khan in the swirling clouds of the Mutara Nebula, memorably returns home and berths at Spacedock, a huge mushroom-shaped space station that controls the flow of traffic to and from Earth. It won't be long until Mars needs one of those, as there are so many missions heading there that Mars space is getting pretty crowded. And in February 2021, there's going to be even more of a traffic jam around the Red Planet as an expeditionary fleet of three spacecraft arrives around the same time.

The United Arab Emirates Hope spacecraft, China's Tianwen-1 orbiter/lander and NASA's Perseverance rover will all send back a wealth of new information about Mars, answering questions and solving mysteries about the planet's past, present and future. Their results will also be used to support efforts to send astronauts to Mars, hopefully some time in the next decade.

Rover upgrade

Without doubt the most advanced and ambitious of the three missions arriving in February is Perseverance. Bigger and more advanced than its lookalike predecessor Curiosity, it has re-designed wheels that NASA hopes won't be ripped open by sharp rocks like Curiosity's have been. Nuclear-powered Perseverance will groan under the weight of multiple scientific instruments and more than 20 cameras, as it trundles across the floor of its landing site – Jezero Crater – looking for evidence of past Martian life. Perseverance will also collect rock and soil samples from different sites along its route, ▸

NASA/JPL/TEXAS A&M/CORNELL

A Martian day closes: the Sun slowly sets on Mars in this image captured by NASA's Spirit rover in 2005

Clues about the past: the arms of an ancient river delta in Jezero Crater are clearly visible in this image that shows the area where the Perseverance mission will land

▸ storing them in tubes on the Martian surface for a future robotic mission to collect and bring back to Earth for analysis.

One of the most exciting aspects of Perseverance's mission is that it will be carrying a passenger – a small drone-like helicopter, Ingenuity, which will scout the terrain ahead of the rover and explore sites beyond its reach. It is not expected that Ingenuity will last long, but it's unwise to bet against a machine sent to Mars: Opportunity's team hoped she would last 90 days – she ended up surviving for 14 years and drove more than 45km across the surface of Mars.

Jezero Crater was chosen as Perseverance's landing site because it was once home to an ancient river delta. The 'arms' of this delta can be seen reaching across the crater floor in images taken from space, and will be studied in great detail by Perseverance and her instruments. The photos taken within Jezero will be the most detailed ever captured, and geologists and armchair explorers alike are drooling with anticipation over the HD views they hope to enjoy of its rocky landscape.

Clear skies

The rover will probably also use its cameras to take images after dark of the night sky. This won't be the first time astrophotography has been done from Mars. Previous rovers have taken many images of Earth, other planets and constellations, as well as partial solar eclipses caused by Mars's twin moons, Phobos and Deimos. And the rovers even managed to photograph the comet Siding Spring during its close encounter with Mars in 2014.

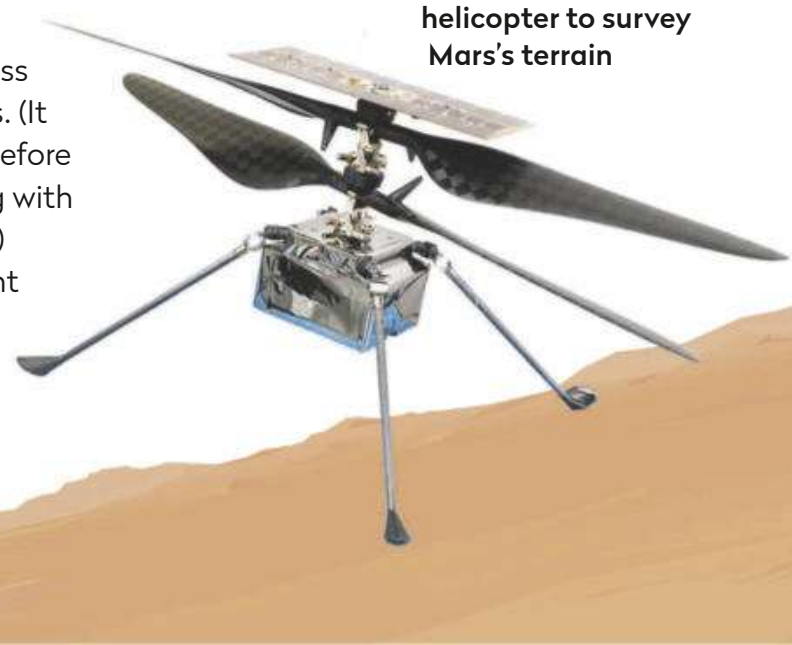
All of which begs the questions: what would a future *Sky at Night Magazine* reader working or living on Mars see during a night's stargazing? Would Mars even be a good place to do amateur astronomy?

▲ **Moon shots: the Curiosity rover captured this set of images as the moon Phobos passed directly in front of the Sun**

At first glance the answer would be a resounding 'yes'. For a start there are very few cloudy nights on Mars. We know it does have some clouds because they have been photographed by every orbiter, rover and lander that has ever been there, and occasionally dust storms brew up which can cover the whole sky for months. However, generally speaking, the Martian night sky would usually be as clear as a clear desert sky here on Earth. You would see two moons in that sky instead of one, and there would be a lot less interference from satellites. (It is likely to be a long time before Mars's night sky is crawling with trains of Starlink satellites.)

On the downside, twilight lasts longer on Mars because of all the extra light-scattering dust in the air. That same dusty

▼ **Flying over Mars: Perseverance will launch the Ingenuity helicopter to survey Mars's terrain**



NASA/JPL-CALTECH/ASU, NASA/JPL-CALTECH/MALIN SPACE SCIENCE SYSTEMS/TEXAS A&M UNIV, NASA/JPL-CALTECH, NASA/JPL-CALTECH/CORNELL UNIV./ASU/TAMU, CHART BY PETE LAWRENCE, DOTTEDHIPPO/ISTOCK/GETTY IMAGES

The Opportunity rover captured this view of Comet Siding Spring as it passed near Mars on 19 October 2014

"You would see a sunset dyed purple and blue, the Sun reduced to a shrunken blue coin before it set behind extinct volcanoes"

atmosphere will also reduce the brightness and visibility of the stars at low altitude, just as low-lying fog does here.

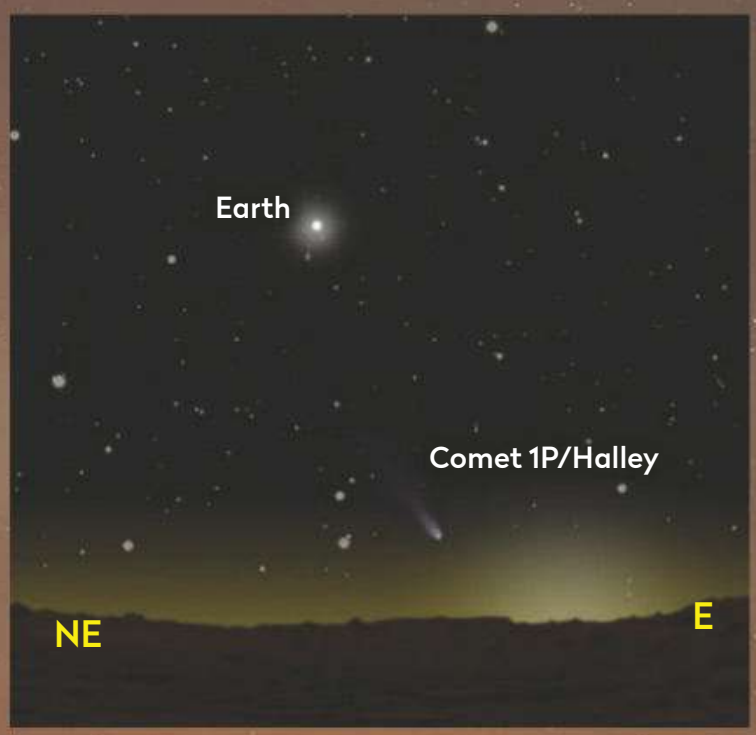
So, what would you see in the Martian night sky? Emerging from the base at dusk, the first thing you would see over the rocky landscape would be a beautiful sunset. On Earth, sunset skies are painted a Turner-esque palette of copper and gold, with the Sun looking like a bloated orange ball. On Mars, thanks to the dusty atmosphere, you would see a ►

Spacesuit stargazing

The practicalities of amateur astronomy on the Red Planet

Future amateur astronomers on Mars will have to be tough and resilient. They might not have to cope with the frustration of cloudy nights like their terrestrial counterparts but they will have other, greater, challenges. For a start, they will have to see and do everything cocooned inside a spacesuit protecting them from the inhospitable Martian environment. Night-time temperatures can drop to -90°C, so fingerless gloves and a woolly hat are not going to be warm enough. So even before going outside to stargaze they will have to spend hours suiting up and then cycling through an airlock.

Once outside, the real challenges will begin. Sadly, there will be no escape from light pollution, even on Mars. Stargazers will have to get away from light produced by the base, but not so far away that their safety is put at risk. Once their vision is dark-adapted they will have to view the starry sky through their helmet visors, which might distort the stars or affect their colours. Using binoculars or telescopes will be difficult for the same reason, although it is possible they might be able to use some sort of visor attachment to let them look through the eyepieces of such observing equipment.



▲ Future observing: a simulated view of Halley's Comet and Earth from the Red Planet's surface

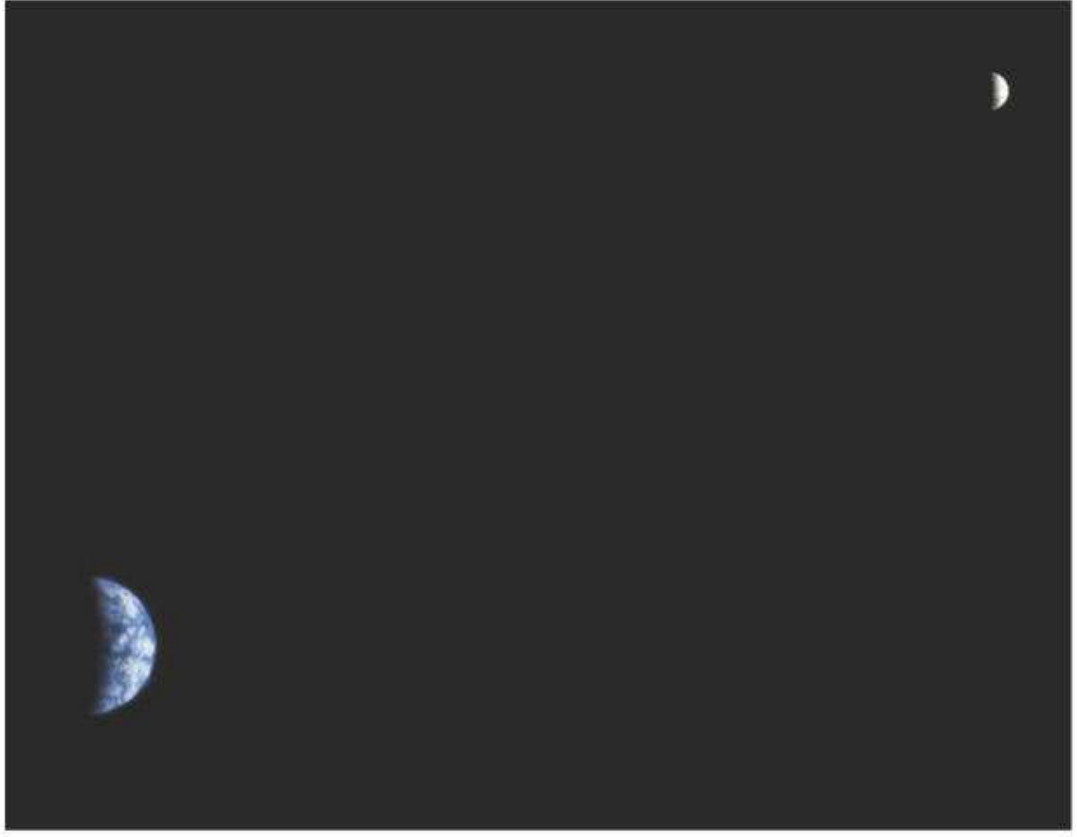
As for astrophotography, the DSLR they used back on Earth won't cut it on Mars. These cameras aren't designed to be used in such a dusty and lethally cold environment, and would probably die within a few minutes of being put on their tripod. But a camera specially designed to be used on Mars would take fantastic images of the stars, planets and Milky Way shining above the planet's jagged mountains, meandering canyons and towering volcanoes. Perhaps the winning image of the Astronomy Photographer of the Year 2061 competition will be a twilight photo of Halley's Comet shining below Earth, high above the dust-covered Opportunity rover.

ILLUSTRATION

► sunset dyed purple and blue, with the faraway Sun reduced to a shrunken blue coin before it set behind the extinct volcanoes silhouetted on the horizon. Photos taken by Curiosity suggest that once the Sun had set there's a good chance you would see streaks and curls of silvery-blue noctilucent clouds shining in the twilight, perhaps even a display putting anything seen in our own summer skies to shame.

Depending on the time of year, you might also see an 'Evening Star' shining in the lavender-hued twilight – Earth, a strikingly-bright spark of silvery blue, which at its best would blaze brighter than mag. –2.5. If Earth was showing a full or gibbous phase, through your telescope you would clearly see its familiar green continents and blue oceans on the dayside, and the lights of its cities glinting on the nightside. And just imagine what an incredible sight a crescent Earth would be through your highest-powered eyepiece.

As the sky darkened, the stars that'd begin to pop into view would look reassuringly familiar: Mars is so close to Earth that none of the stars would look any brighter or fainter than they do from Earth. As there is no shift in parallax to rearrange the constellations into new shapes, you would still see Cassiopeia, Orion the Hunter, and all your other favourites. However, if you're a Martian you might know them by different names, or might have totally different constellations altogether – native-born Martians of the future will almost certainly re-draw the night sky to celebrate their own history and key figures.



▲ **Mars, Earth and the Moon, captured by NASA's Mars Reconnaissance Orbiter on 3 October 2007**

However, as you set up your telescope a problem would quickly present itself: Mars has no 'North Star', like Polaris here on Earth, to align on. Instead, its axis of rotation points at an unremarkable area of sky close to Alderamin (Alpha (α) Cephei), the brightest star in Cepheus. Deneb (Alpha (α) Cygni) is the closest bright star to Mars's northern celestial pole.

Lunar pageant

Our Moon crawls relatively slowly across the heavens. In contrast, Mars's two moons, Phobos and Deimos, move far more rapidly across the sky. To the naked eye Phobos would resemble a pale pebble one third as wide as Earth's Moon, while Deimos would appear more like a bright star. But both would shine brightly enough to cast your shadow on the rocks and dust dunes around, as you watched them drift overhead. And, as the moons move across the night sky, if you could keep them in your telescope's field of view, it would reveal their irregular, lumpen shapes and largest craters.

Planet-spotting on Mars would be great fun. Although Mercury and Venus would be fainter than they appear from Earth, Jupiter and Saturn would

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books. He enjoys processing raw Mars mission images to create colour panoramas

High sights: a spectacular display of Martian noctilucent clouds, as captured by the Mars Curiosity Rover in May 2019

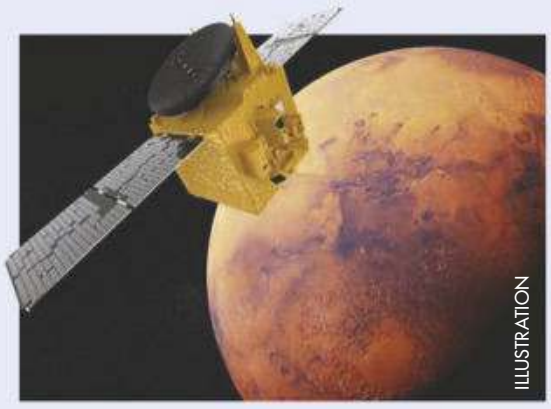
NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA, NASA/JPL-CALTECH, CHART BY PETE LAWRENCE, NASA/JPL-CALTECH, MBRSC (MOHAMMED BIN RASHID SPACE CENTRE), PETMAL/ISTOCK/GETTY IMAGES, CNSA

Northern sights: with no 'North Star' in the Martian sky, Mars-based observers will need to use the bright star Deneb to help locate the north celestial pole

Arrival of an armada

In February 2021, three missions will complete the lengthy voyage to Mars

HOPE
The UAE's Emirates Mars Mission orbiter Hope will study daily and seasonal Martian weather cycles and dust storm activity in its lower atmosphere. It will also try to learn why Mars is losing hydrogen and oxygen into space, and why its climate drastically changed in the past.



ILLUSTRATION

TIANWEN-1
Tianwen-1 is a mission by the China National Space Administration (CNSA), comprising an orbiter, a lander and a rover, which bears more than a passing resemblance to NASA's Spirit and Opportunity rovers. It will land in Utopia Planitia to search for evidence of both current and past life.

ILLUSTRATION

PERSEVERANCE
After its 'Seven Minutes of Terror' descent, NASA's nuclear-powered Perseverance rover will be gently lowered down to the Martian surface using the same '*Thunderbirds*-esque' Skycrane technology that successfully delivered the Curiosity rover to the Red Planet back in 2012.

ILLUSTRATION

sometimes appear much brighter. When the two gas giants were at their closest to Mars both would show fascinating detail through your telescope.

With no light pollution or bright Moon to dim the Milky Way, it would be a spectacular sight from Mars. Just imagine standing on the crumbling edge of the great Valles Marineris, or the lofty summit of towering Olympus Mons, and seeing the Milky Way painted across the sky, stretching from horizon to horizon, its length clotted with frothy star clouds.

Meteor showers

As you stood there hypnotised by the beauty of the Milky Way you might see a meteor zip across the sky. Despite Mars having quite a pathetic excuse for an atmosphere, it is still thick enough to produce meteors. If you had been standing beside Opportunity in 2014 when Mars passed through the tail of Comet Siding Spring, you would have seen a display of shooting stars rivalling the famous Leonid storms of the past. Such events are very rare of course, but research suggests Mars has its own meteor showers, although they don't occur on the same dates as Earth's.

If you're a deep-sky observer you would also be able to see all your favourites from Mars. However, your views of incredible sights such as the Orion Nebula, the Andromeda Galaxy and the Pleiades star cluster might be ruined by the fact that it would be difficult to get close to your telescope eyepiece due to the bulky visor of your spacesuit helmet.

Eventually the sky would begin to brighten, a violet-blue glow spreading over the eastern sky until the Sun burst over the horizon, flooding the landscape with light. The Martian stars would be snuffed out one by one, until only the brightest planets remained, then they too would fade away, leaving the sky a blank, orange-pink dome once more. And another Martian day would begin.

The strange world of robotic SPACE EXPLORATION

Ezzy Pearson looks at some of the more curious stories from the footnotes of planetary exploration

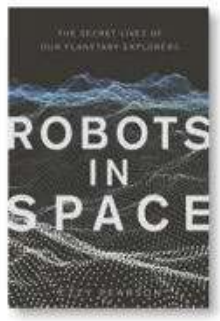
For over 60 years, humanity has been pushing ever further out into the Solar System, exploring our seven sibling planets and their many moons, as well as countless asteroids. Yet we've done this all from a distance: it isn't people that have been making the journey, but robotic spacecraft. While humans have yet to stray far from Earth, robots have been to the hellish surface of Venus, ranged the hills of Mars and bounced across asteroids.

Their road to the heavens has been far from a straight one. Along the way there have been dozens of false starts, fallen hurdles and unexpected twists. Here are some of the more surprising tales from the journals of robotic planetary exploration.

ILLUSTRATION

Taking the heat: a Russian Venera space probe endures the extreme temperatures on the surface of Venus

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor. Her latest book *Robots in Space* has recently been published by The History Press



Viking's team photo

STOCKTREK IMAGES, INC/ALAMY STOCK PHOTO, NASA/JPL X 3

A field trip to test NASA's first Martian camera offered a unique photo opportunity

▲ **Test shot: the team that built the Viking spacecraft – see if you can spot the members who appear twice**

In the 1970s, NASA had its sights on Mars. The agency built an impressive pair of spacecraft named Viking which would, they hoped, take the first ever panorama from the Red Planet's surface. With such an important task resting on having cameras that worked, it was with horror that Thomas Mutch, the head of the Viking landing team, discovered that the engineers intended to send the instrument to Mars without having taken a test photo. The build team reassured him that if they tested every component separately then the whole instrument would definitely work, but he was sceptical.

After much haranguing, Mutch convinced them to let him take the camera for a test drive. The team took a quick test photo in the car park at ITEK where the cameras were being built, before loading millions of dollars of irreplacable equipment into a van and then driving to a national park, to test them in a more 'Mars-like' environment. As the test went smoothly, the crew took a quick team photo, taking advantage of the camera's slow scanning speed to run around the back and appear in the image multiple times (see above). ►

▲ **Landmark views: the Viking landers went on to take incredible images of the rocky Martian landscape**

Opportunity comes unstuck

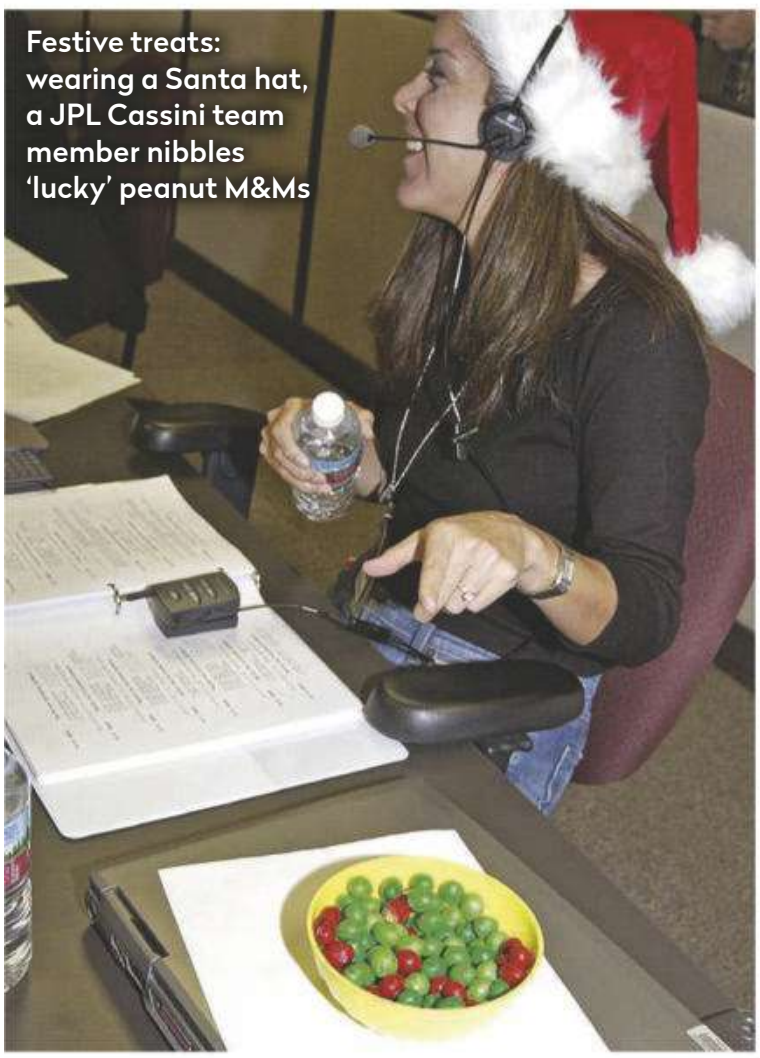
An unusual material almost scuppered the Mars rover's launch

On 29 June 2003, the Opportunity rover was on top of a Boeing Delta II rocket, ready to begin its voyage to Mars after being delayed due to bad weather. Inspectors were busy checking over the rocket to see if it had been damaged overnight when they discovered something peeling off the side of the launcher – a layer of cork.

You read that right: cork. Delta rockets are coated in a layer of the tree bark to help distribute heat during take-off. In this case, several of the panels had been put on sideways, allowing water to seep in and dissolve the glue. With the launch window rapidly advancing, the Boeing engineers exchanged frantic phone calls with the adhesive manufacturers, trying to get the panels stuck back on.

Fortunately, they managed it and on 7 July, 11:18pm local time, Opportunity began its journey to Mars. Only a few of the build team had stayed behind to watch the late launch but among those few were a pair of bagpipe players, Mary Mulvanerton and Jon Beans Proton, who accompanied the launch with the comforting drone of *Amazing Grace*.

Sticky situation: the Opportunity rover was successfully launched on a Delta II rocket after the rocket's panelling had been glued back on



Festive treats: wearing a Santa hat, a JPL Cassini team member nibbles 'lucky' peanut M&Ms

Planetary peanuts

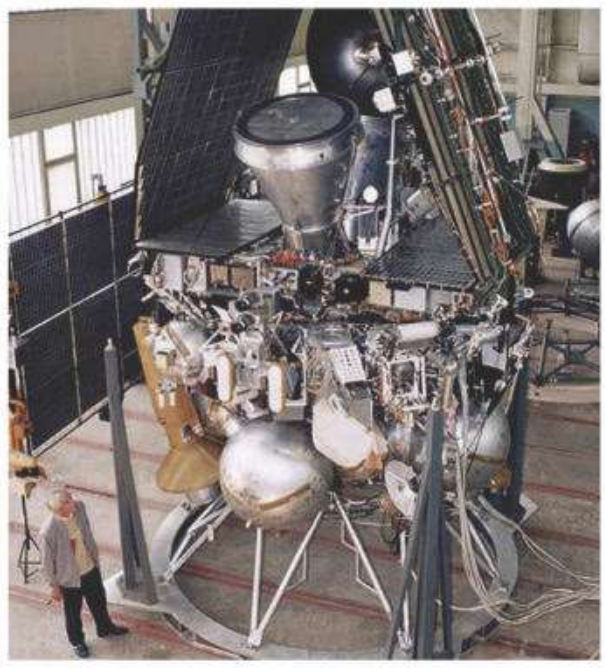
Lucky legumes have been launch day fare at JPL for over 50 years

In the early 1960s, NASA was not having much luck with lunar landers. Its Ranger project was meant to be destructively impacting a spacecraft into the Moon, taking photographs as it went. Yet, after six attempts NASA hadn't even been able to crash onto the Moon.

NASA's luck finally turned on 31 July 1964, when Ranger 7 impacted. The reason for the success: careful engineering and learning from past mistakes... or was it the fact that someone had brought peanuts into the control room at the Jet Propulsion Laboratory (JPL) that day? Whichever is actually responsible, tradition has deemed that it was the 'lucky peanuts' that did the trick. Ever since, almost every major planetary milestone controlled from JPL has been watched over by the auspicious nibbles. Normally these are jars of regular peanuts, but when Cassini released the Huygens lander towards Saturn's moon Titan on Christmas Eve 2004, it was festive bowls of red and green M&Ms – the peanut variety, naturally – that were spread throughout the control room.

NASA/JPL-CALTECH X 2, NASA/JOEL KOWSKY, ALEXIS GONZALEZ/ISTOCK/ GETTY IMAGES, NASA X 2, NASA/JPL/CORNELL UNIVERSITY

▲ **Mission impossible: to this day Mars 96 remains lost somewhere in the remote rainforests of Chile**



► **Even from the outset, the probe's development was fraught with financial and political problems**

No money for Mars

Through power and pay cuts, Russian workers persevered with their Martian mission

In 1991, the Soviet space programme was hard at work on Mars 94, due to launch in three years. While things had been going well for the mission, the same wasn't true of the nation, and in December the Soviet Union collapsed to become Russia and the Commonwealth of Independent States. The Mars 94 mission now found itself spread across multiple countries, each of which was frantically trying to set up something resembling a stable government.

As space wasn't high on anyone's funding priority lists, the mission made faltering progress as money dripped in and ran out. The launch was pushed back and Mars 94 became Mars 96, while nationwide power cuts meant a spacecraft intended to travel to the stars was being built by unpaid workers, operating by candlelight and being kept from freezing by kerosene heaters.

Mars 96 did make it to the launch pad, but not much further. After failing to reach orbit, the lander – and its plutonium power source – dropped somewhere into the rainforests of Chile. As the Russians couldn't afford to retrieve it, no one is really sure of its whereabouts to this day.

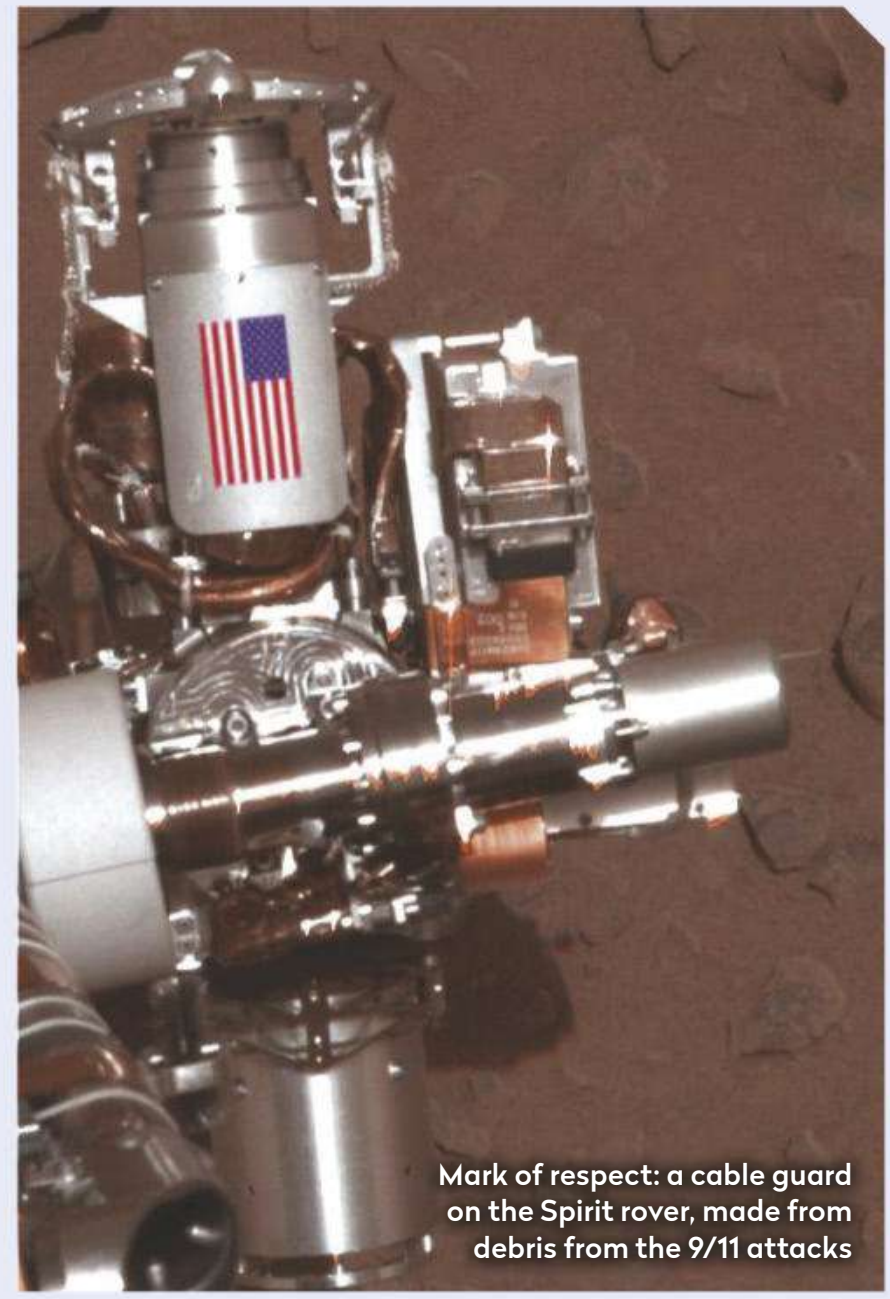
A Martian memorial

Debris from the 9/11 attacks now rests on Mars

On the morning of 11 September 2001, Steven Gorevan of Honeybee Robotics was heading into the company's office in lower Manhattan. He and his team were due to spend the day working on the rock abrasion tools (RATs) – instruments which grind away a rock's surface to reveal pristine material beneath – which the company was building for NASA's Mars Exploration Rovers, Spirit and Opportunity. But he never started work that day. While cycling into the office at 8:46am, Gorevan heard the sound of an aeroplane overhead flying unusually low, just before it impacted with the North Tower of the World Trade Centre, six blocks away.

In the weeks following the 9/11 attacks, the staff at Honeybee struggled to return to normal. JPL engineer Steve Kondos, who was working with the team, wondered if they could include some of the wreckage of the towers in the instruments. They contacted the offices of Mayor Rudi Giuliani and a few days later a box was delivered to the Honeybee office. Inside were a few fragments of twisted metal and a note reading 'Here is debris from Tower 1 and Tower 2'.

The Honeybee team reverently crafted these pieces into two cable guards to protect the RAT during drilling, each decorated with an American flag. Though the rovers are no longer operating, the cable guards still stand on Mars: a permanent memorial to those who lost their lives on 9/11. ►



Mark of respect: a cable guard on the Spirit rover, made from debris from the 9/11 attacks

Science doesn't stop for cricket

Bernard Lovell's refusal to bail meant he almost missed the first lunar landing

In the early days of the Space Race, the Soviets were very much in the lead: Sputnik had been the first satellite in orbit; the ill-fated dog Laika was the first living animal in space; and the Soviet Luna 1 had been the first spacecraft to reach the Moon's vicinity. However, the Soviets had a policy of not announcing their missions until they'd already been successful, leading to allegations the whole thing was a communist conspiracy – the Great Red Lie.

These suspicions were largely swept away, however, by the huge radio telescope at Jodrell Bank, just outside Manchester, which was watching every mission and could clearly see their radio signals emanating from space. On 13 September 1959, the Soviets were preparing for their Luna 2 spacecraft to not just pass the Moon but to crash into it. It would be the first time humanity had actually contacted another world and the Soviets didn't want there to be any doubt. They wanted the observatory's director himself, Bernard Lovell, in the control room.

They really should have checked the schedule ahead of time, however, as the landing fell on a Sunday and Lovell had far more pressing matters to attend to – umpiring his local cricket match. Initially, Lovell refused to even contemplate returning to work. It was only when he received a call from the top brass in Moscow that he ditched his cricket whites and returned to Jodrell Bank to watch the historic event.

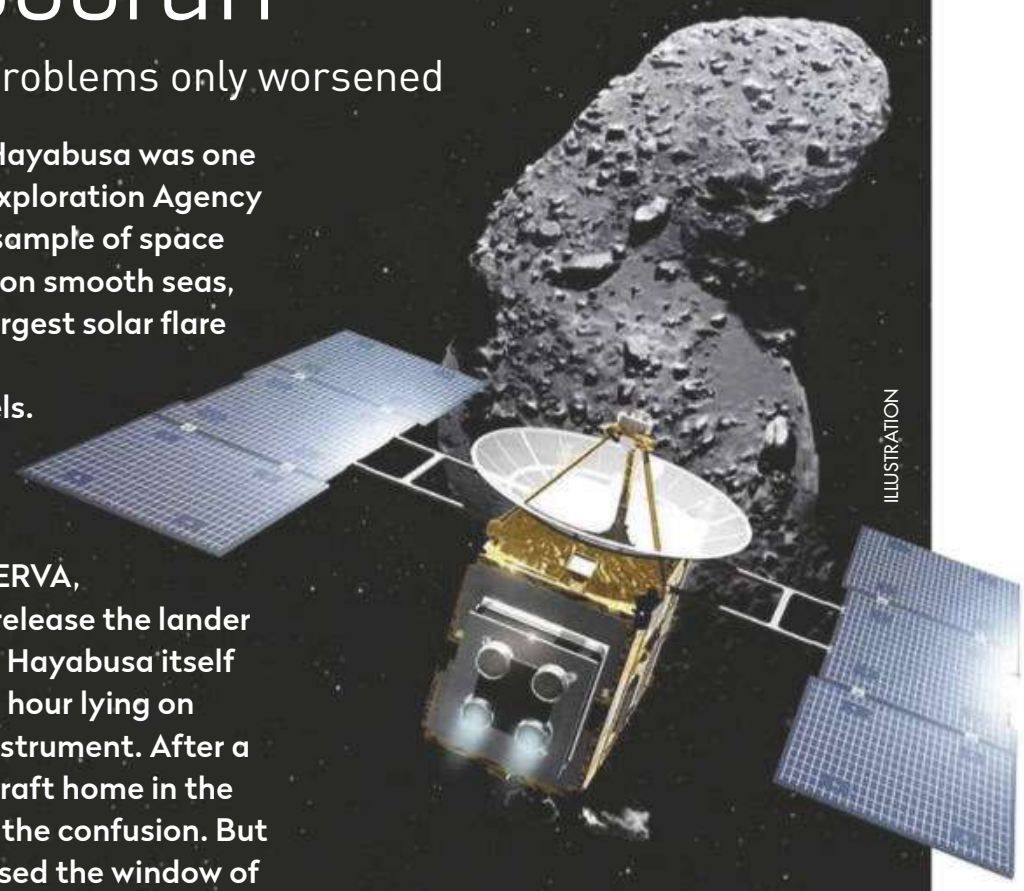
▲ Almost out: Lovell displays 'radio' images of the Moon from Russia's Luna 9 in 1966. He almost missed their first landing in 1959 due to a game of cricket

The unluckiest spacecraft

After being struck by a solar flare, Hayabusa's problems only worsened

Launched on 9 May 2003, the asteroid-investigating mission Hayabusa was one of the first planetary spacecraft of the Japanese Aerospace Exploration Agency (JAXA). Its mission was to approach asteroid Itokawa, take a sample of space rock and return it to Earth. While at first the spacecraft sailed on smooth seas, things took a turn for the worse in November 2003 when the largest solar flare on record erupted, washing straight over Hayabusa.

The radiation severely damaged the spacecraft's solar panels. But Hayabusa flew on, arriving at Itokawa in September 2005 only to reveal that two of the three reaction wheels that kept the spacecraft steady were broken. Then when the spacecraft attempted to release a mini-lander, known as MINERVA, a safety protocol caused it to back off at the last minute and release the lander from completely the wrong place. Things only got worse when Hayabusa itself moved in to take its rock sample. It ended up spending half an hour lying on the rock, soaking in its heat, without deploying its sampling instrument. After a second attempt also failed, JAXA decided to bring the spacecraft home in the hope that some asteroid dust might have been swept up in all the confusion. But when Hayabusa briefly lost communications with Earth, it missed the window of opportunity to launch – its journey would now take another three years. It finally arrived back in 2010, with less than a milligram of material onboard.



ILLUSTRATION

Out of control: the ill-fated Hayabusa at asteroid Itokawa

KEYSTONE PRESS/ALAMY STOCK PHOTO, CMANNPHOTO/ISTOCK/GETTY IMAGES, ROBYNMAC/ISTOCK/GETTY IMAGES, JAXA / ISAS, NSSDC PHOTO GALLERY X 2, NASA

▲ **From the surface: some of the first images of Venus taken by Venera 9 (top) and Venera 10 in October 1975**

Don't forget to take the lens cap off!

The 'first' colour images from Venus were ruined by a stuck covering

The surface of Venus isn't the best environment to operate a spacecraft in. The surface is hot enough to melt lead, while the pressure is 92 times that of Earth at sea level and the air is filled with caustic chemicals. Yet, it was the Soviet Union's Venera missions to this hellish world that were the nation's most successful planetary campaign.

The initial landers were simple, but by the time the Venera 9 and 10 spacecraft touched down in October 1975, they had been refined enough to be equipped with a pair of black and white cameras that would take the first ever image from another planet's surface. The pressure had been too much, however, and both of the landers ended up with one of their lens caps sticking. Though they couldn't capture the full 360° panoramas they'd intended to, the images still grabbed headlines around the world.

When the next pair of Venera missions, 11 and 12, came around in 1978, they'd been upgraded with colour capable cameras... so it was even more galling when the 'images' came back and revealed that every single lens cap on both rovers had been stuck yet again. By the time Venera 13 touched down in 1982 the problem had finally been fixed and it could take its colour photos with both cameras.

Turn the air-conditioning down

Always be sure to double-check the fan before cooling a spacecraft

At a distance of 1.5 billion km from the Sun, Saturn is a dim planet. As such, NASA couldn't rely on solar panels when they were designing the Cassini spacecraft to investigate the planet. Instead they used a radioisotope thermoelectric generator, which converts heat from a radioactive brick of material into electricity. These also have the added benefit of working as a very efficient heater to keep your spacecraft warm in the cold of space. You can't turn off a nuclear heater, however, and this created something of a problem when, in the autumn of 1997, Cassini was being prepared for launch at Cape Canaveral in the Florida heat. The spacecraft had to be constantly air-conditioned but, when the fans were turned on, the blowers had been set 10 times too high. The powerful air blast shredded the spacecraft's insulation, firing small particles through the billion-dollar spacecraft. The crew had to rapidly unload the spacecraft, clean it out and hope there wasn't any damage they couldn't see. As the Cassini mission would go on to last almost 20 years, it seems they were okay.

Nuclear battery: scientists install a radioisotope thermoelectric generator on Cassini

DIY ASTRONOMY

FAMILY FRIENDLY PROJECT

Make a model of a comet

Get familiar with the parts of a comet by building a model from household materials

Comets are some of the most interesting astronomical objects to observe. Many of us will have enjoyed Comet NEOWISE during the summer of 2020, but these dusty ice balls have been studied for millennia. Early observers treated them with suspicion as they were linked (incorrectly) to natural disasters, and often thought to signify the death of noblemen. Hence, their label 'Harbingers of Doom'.

Comets are icy bodies comprised of rock, dust, water ice, frozen volatile compounds and some also contain long-chain hydrocarbons and amino acids. They were formed from materials left over following the formation of the Solar System. The nucleus of a comet is usually between a few hundred metres and a few tens of kilometres across. When their orbit brings them into the inner Solar System, solar radiation causes some of the volatile compounds to vaporise out of the nucleus; this gas and dust forms a slight atmosphere around the comet, called the coma. The exact size of the coma varies from comet to comet. It often has a greenish colour to it because ultraviolet light from the Sun ionises molecules of cyanogen and diatomic carbon within the coma, which causes the ions to fluoresce green.

Talking point: making a model comet can be a teaching opportunity

The tails

As a comet gets closer to the Sun, the radiation pressure from the solar wind causes the tails to form. Comets often have two distinct tails; a dust tail and an ion tail. The dust tail is material left behind as the comet speeds through space; dust tails are usually curved, are a white and yellow colour because they reflect sunlight and are normally between one and 10 million kilometres in length. The ion tail, or plasma tail, is comprised of ionised particles. As they interact with the solar wind, the ions flow out at high speed in a straight line directly away from the Sun. Ion tails are often a glowing blue colour due to ionised carbon monoxide. They are tens of millions of kilometres in length. Some rare exceptions reach a whopping 3.8 AU long, where 1 AU (astronomical unit) is the distance between Earth and the Sun. Because the comet's nucleus is usually rotating, both tails may have twists and turns in them.

Making models is a great way to learn about an astronomical object. Here we show you how to make a model of a typical comet using very basic materials that you probably have lying around at home. This is an excellent project to do with children, because the model contains different components for each part of a comet and it therefore provides a great teaching opportunity during each step of the model-making process.

For the stand we used a gift box that still had its insert, giving an extra layer of support for the wooden skewers. Some Blu Tack under the holes will also give something extra to hold the skewers in place. Made like this, the stand should be sturdy enough to support this very lightweight model, but if you need some extra weight, fill the box with rice or sand.

Mary McIntyre is an outreach astronomer and teacher of astrophotography

What you'll need

- A 3cm or 4cm diameter polystyrene ball; if you don't have one of these, use a ping pong ball instead
- One white foam A4 craft sheet (or white card), which will form the underlying structure of the dust tail, plus a cocktail stick
- Some cotton wool or cotton wadding for creating the coma and dust tail
- Two blue pipe cleaners and a piece of blue or silver craft wire for the ion tail
- A small gift box, preferably black, and two barbecue skewers to form the stand; the box we used measures 12cm x 8cm x 3cm

ALL PICTURES: MARY MCINTYRE

Step by step

Step 1

Using hot glue, stick a cocktail stick in the middle of the long edge of the foam sheet with about a third over the edge. Tightly fold the sheet into a cone shape, securing with staples and hot glue. Stick the cone into the polystyrene ball using the cocktail stick.

Step 2

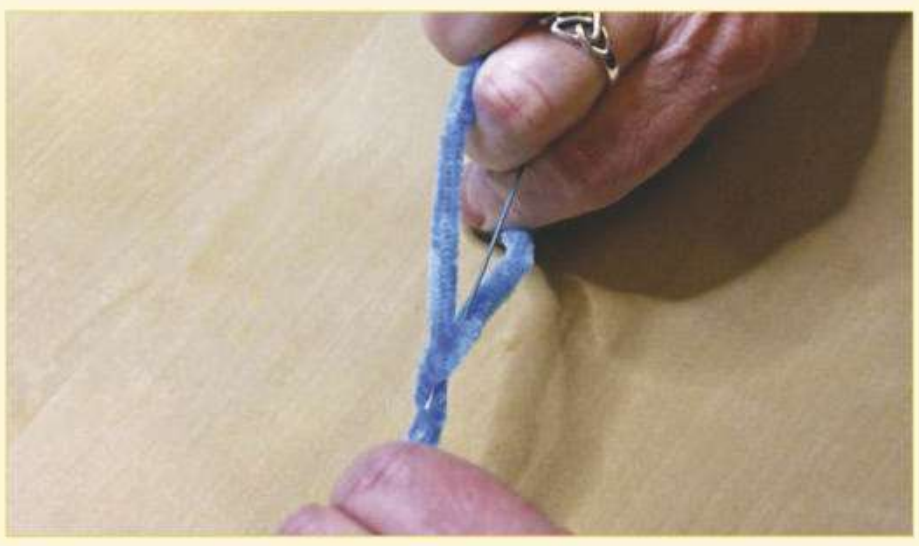
Cover the ball with cotton wool to form the coma and then cover the entire foam sheet with cotton wool or wadding using water-based glue. Tear the ends off rather than cutting them so the end of the tail has an uneven edge.

Step 3

Fill the cone with cotton wool or wadding, then glue a long strip of cotton wool around the edge, continuing inwards in a spiral pattern. Then gently pull, tease and twist all the edges to form an irregular dust tail shape. Use hairspray to hold the strands in place.

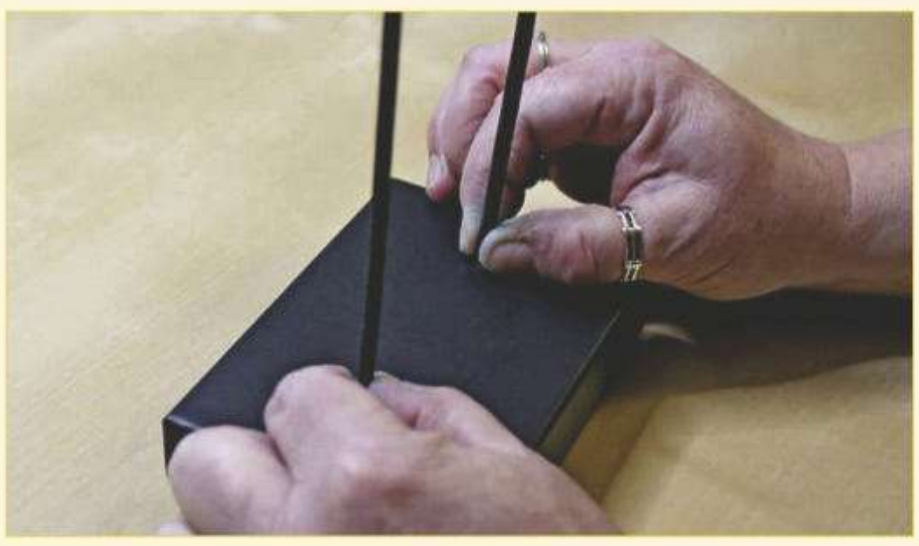
Step 4

Remove the tail, then paint the outside of the nucleus (or coma) pale green using a water-based paint. This recreates the classic green colour of the coma around a comet's nucleus. Leave this to dry. Once dry, re-attach the tail.



Step 5

Twist together the two pipe cleaners with a length of craft wire to form the ion tail. Leave a short length of wire at one end which you can fix into the polystyrene ball. Make sure that you stick the ion tail into the nucleus/coma at a different angle to the dust tail.



Step 6

Make two holes about 8cm apart in the box lid. Paint two wooden skewers black and trim the blunt ends. One skewer needs to be 17cm, the other 22cm. Push the blunt ends through the box holes, then push the pointed ends through the nucleus and tail.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Imaging the thin crescent Moon

How to capture a sharp shot of our natural satellite early or late in the lunar month

The year 2021 will present several great opportunities for observing and imaging thin lunar crescents, either approaching new Moon in the morning sky or moving away from new Moon into the evening sky. A morning crescent represents a time when we're seeing the illuminated portion of the Moon's globe apparently diminishing in size: a waning crescent Moon. An evening lunar crescent represents a time when we're seeing the Moon's phase growing: a waxing crescent Moon.

The term 'young' or 'old' when used to describe the Moon's age refers to where the Moon sits in its 29.5-day synodic month – the complete cycle of phase of the Moon as seen from Earth. This period is defined to reset at new Moon (age equal to 0 days), and grow thereafter, resetting to zero again at the next new Moon. A young lunar crescent is one which is less than a few days old. An old lunar crescent is one which is further in the synodic month than a few days before new Moon.

▲ **Imaging the sliver of a thin crescent Moon can be challenging**

Locating the Moon

Imaging the Moon under dark-sky conditions is fairly straightforward. Such a Moon is easy to locate and focus on because it's bright against the dark sky. Old or young crescents present as thin slivers of illuminated lunar surface and, for this reason, appear less bright than they would in their fuller phases. Thin crescents occur when the Moon is near to the Sun in the sky and this also hinders visibility, the crescent being easily lost against the bright twilight backdrop.

Here we have a problem: in order to photograph such a Moon well, it's essential to achieve sharp focus. Being so thin, even a small deviation from the true focus position of your camera lens or scope may cause the Moon's light to spread into a blur that is lost against the background sky.

One way around this is to pre-focus at infinity the night before. For a camera lens this requires it to be set to manual focus before carefully focusing on a distant object, such as a bright star or planet. A piece of low tack electrical tape can then be used to carefully 'lock' the lens's focuser ring in place, hopefully holding it secure in readiness for your next thin Moon attempt.

This technique doesn't always work. Variations in temperature during the day or inadvertently knocking the focus ring, even while stuck down, may cause a change in focus. It's better to focus on something a long way off before your attempt on the Moon. For waning crescents that appear in the morning sky, this will mean getting up early to take advantage of a dark pre-dawn twilight sky using a bright star or planet for focus. For waxing crescents, the situation is trickier; focusing on the Sun is the better option, but this requires the use of a white light solar safety filter on the lens or scope to keep things safe. As ever, remember to follow solar safety precautions.

Once focused, the hard part is done and by following our guide steps opposite, you'll be able to grab yourself one of 2021's ultra-thin Moons. Once you've caught one, you'll be hooked to try for more!

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

Recommended equipment: DSLR camera, tripod, shutter-release cable, lens with a focal length between 200-1,000mm

✉ Send your images to:
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

STEP 1

Homework is important for thin Moon attempts. Determine where the Moon is relative to the Sun and work out where it will be relative to the horizon after sunset. Choose a shooting location where the horizon appears low and unobstructed. A clear sky is best, as haze or low cloud will hide the crescent from view.

STEP 2

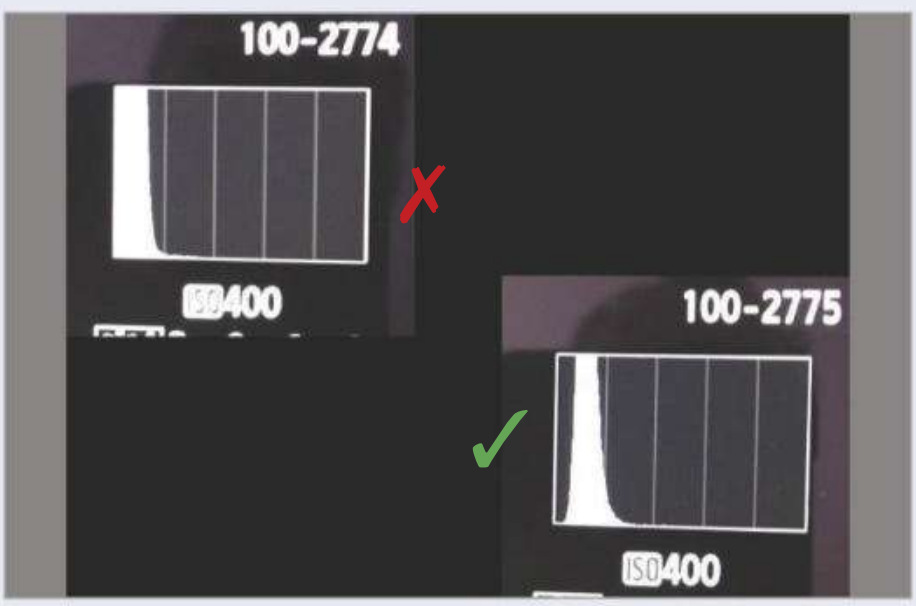
If you plan to use a lens, choose one which will show a good crescent. This typically means something with a focal length starting around the 200–300mm mark. A 1000mm setup (typically achieved using a telescope) will give you a good crescent size. A focal ratio between f/9 and f/16 is ideal.

STEP 3

Keep ISO in a low range of 100–1600. Start low and increase for evening sessions, as the sky darkens over time. For morning sessions, start high and lower the ISO as sunrise approaches. See opposite for how to focus accurately. If you can see the Moon on the back of the camera, use that to ensure the focus is sharp.

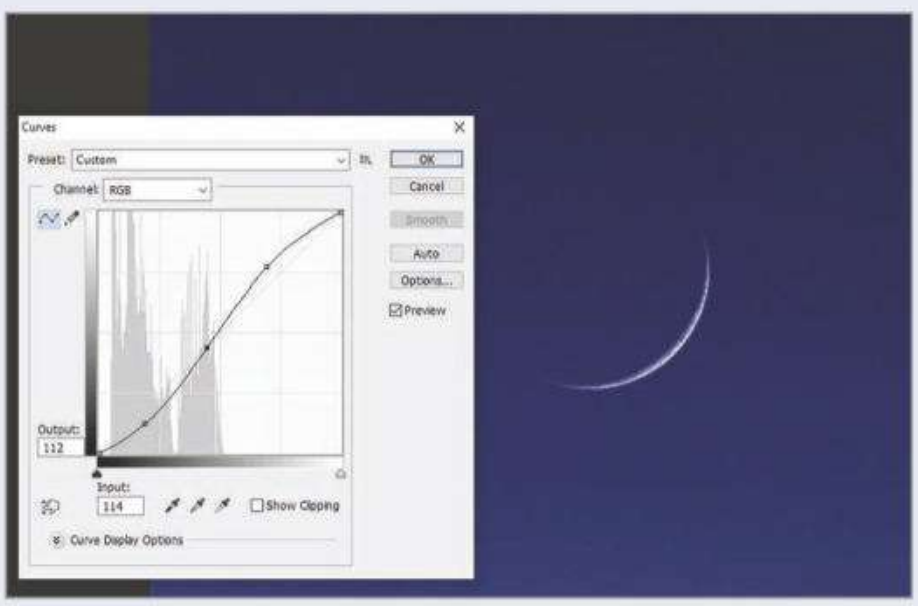
STEP 4

Line your camera up so the Moon is in view. There's a chance you may not be able to see the crescent visually if it's very thin. If so, you'll need to judge where to point your camera relative to the horizon and rely on it being able to record the crescent. Take an image using a test exposure of 1 second.



STEP 5

Examine the result using your camera's histogram display. If the graph is stacked hard to the left or right, you'll need to adjust exposure. If it's too dark, you'll need to increase the exposure and/or ISO; if it's too light, you'll need to decrease the exposure and/or ISO. Aim to get the peak within the left–right limits of the graph.



STEP 6

Load the results into your image editing software. A tweak to the brightness and contrast settings may help bring out the faint lunar crescent. Alternatively, open the curves tool and place an anchor in the centre of the adjustment line, then adjust the curve's shape to become more of an 'S' to improve its visibility.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Using Levels to enhance your astro image

Increase image detail by stretching the data with the Levels tool in image editing software

Our Crescent Nebula image is transformed by stretching the data and adjusting brightness

Processing in astrophotography allows details to emerge and takes several stages. It involves editing an image file that can look dark and flat at first, like our starting image (right), which at first glance appears to contain little or no data. Basically, we are trying to make the image data work as effectively as possible by 'stretching' it. Data stretching is typically done with a 'Levels' function and, if used properly, this will improve image contrast, colours and overall brightness. The Levels tool is found in Adobe Photoshop and the free editing software GIMP, along with several other image-processing programs.

Here, we are using GIMP to stretch our starting image of the Crescent Nebula (right), a DSLR capture that consists of two hours of exposures with a Hydrogen-alpha (Ha) filter and two hours of normal colour (RGB) data. The individual files have been stacked in DeepSkyStacker to produce a TIFF file.

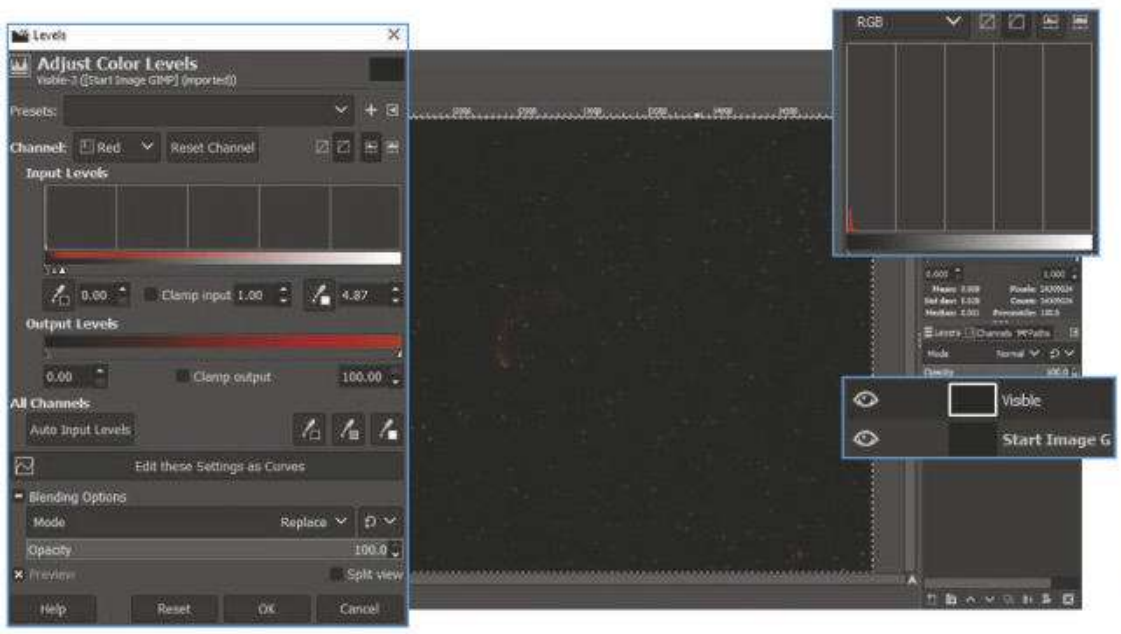
ALL PICTURES: CHARLOTTE DANIELS

After opening the file in GIMP (click 'File > Open > [file name]') the first thing we do is enlarge our image so that it fills the central window (click 'View > Zoom > Fit image in Window'), which allows us to see overall adjustments clearly. To the top right of the screen (see Screenshot 1, opposite, top) there is a histogram showing how data is distributed in our image. By clicking the dropdown box at the top of this histogram and selecting 'RGB', we can see the 'Red', 'Green' and 'Blue' colour channels separately.

Our image layers are shown below (see Screenshot 1, opposite) – the first layer is our base image. Before we make alterations, we duplicate the base image as a new layer by selecting it with the mouse and right-clicking on the layer to select 'New from Visible'. A layer called 'Visible' then appears on top of our base image. This preserves our original image from alterations; if we make a mistake we can just delete the relevant layer by right-clicking the mouse and selecting 'Delete Layer'. For every adjustment we make, we will create a new layer using this method.

We are now ready to adjust our levels and we do this by clicking 'Colour > Levels' to bring up the menu

Before adjusting Levels our image may look blank, but there is plenty of hidden data to bring out



▲ **Screenshot 1: to select the channel to stretch, we click 'Colour › Levels' to bring up the menu and then use the dropdown next to 'Channel' to make our 'Red' selection**

3 QUICK TIPS

1. Perform multiple, small stretches of your data – this prevents you losing important image details.

2. Click the 'eye button' next to a new layer (see Screenshot 3, below) to see if an adjustment has improved your image.

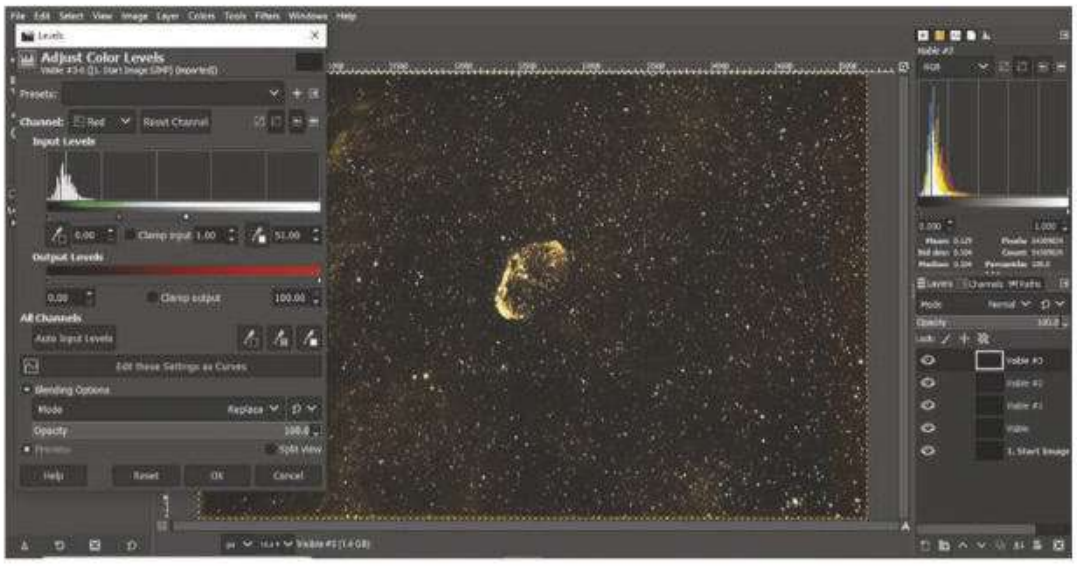
3. Use Levels before any noise reduction to remove unwanted artefacts or filter functions – these should be used at later stages.

(see the top left of the screen on Screenshot 1). We use the dropdown menu next to 'Channel' to select 'Red', the first channel we will stretch. You will see that the data for each channel starts off narrow – by stretching our data we aim to make the data on the histogram wider. We click on the white, right-most arrow and drag it closer to the histogram data. However, we don't move the arrow all the way across to touch the data – we move it enough to see details emerge in that colour channel, but we stop before the image looks noisy, with unwanted artefacts. In our experience GIMP is sensitive – if we drag the right-most arrow too far in one go, we will 'overstretch' our data and lose detail. It is therefore best to perform multiple small stretches.

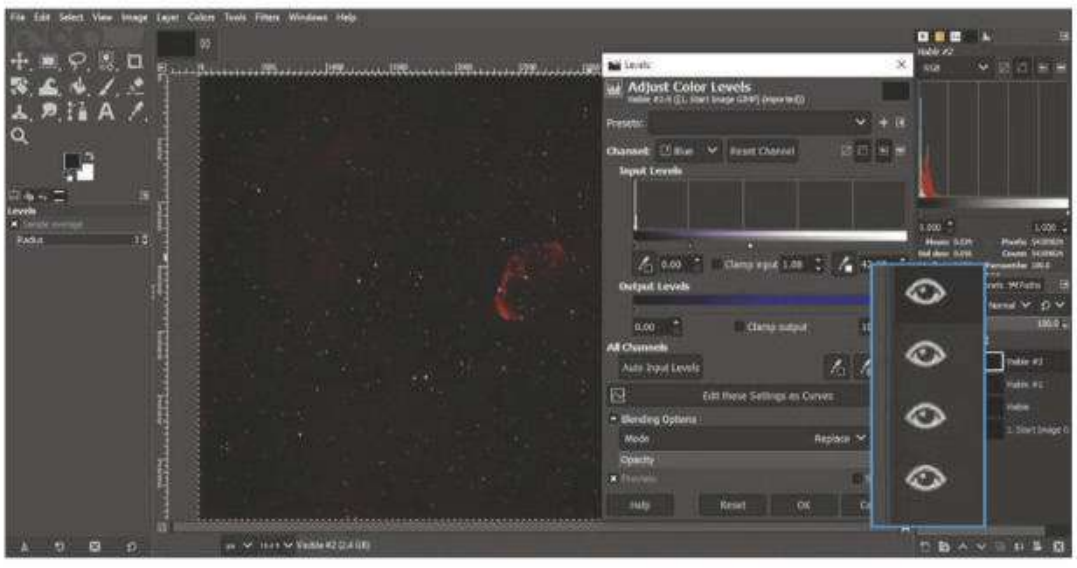
Screenshot 2 (see below, left) is an example of an 'overstretch' – the white regions in our Crescent Nebula show where we have gone too far and have lost the finer detail; the background also looks noisy. While lost colour is difficult to rectify, the lost detail is impossible to recover, so in cases like this it is best to delete the layer and start the adjustment again.

We repeat the stretch process for the 'Green' and 'Blue' channels by clicking and selecting these colours from the 'Channel' dropdown box. Again, we only move the right-most arrow incrementally. After performing each channel's stretch, we use our mouse to right-click on our 'Visible' layer and select 'Merge Down', which adds our adjustment to the previous layer.

We then use our mouse to right click on the merged layer and select 'New from Visible' to create a new layer to work on. Again, the 'Visible' layer appears above the previous layer. We repeat the above process another two times to stretch our data further – selecting 'Levels', and working through the 'Red', 'Green' and 'Blue' channels. Each time, the histogram data becomes wider. If the left-hand edge of the histogram moves towards the right, we also drag the left-most arrow towards the data.



▲ **Screenshot 2: If the Levels adjustment has gone too far and the image is overstretched, it's best to simply delete that layer and start again**



▲ **Screenshot 3: Continue to make and check small stretch adjustments until the right amount of image detail has been achieved**

Stretching out

Each small stretch allows additional details and contrasts to appear in our image (see Screenshot 3). It's still possible to overstretch our data, even with small stretches, but after three passes we're confident we've extracted all we can using 'Levels' for this file.

Finally, in order to show fainter details from our stretch, it helps to adjust the image brightness – we can use the 'Shadows-Highlights' function; by clicking 'Colors › Shadows-Highlights' and dragging the 'Shadows' bar to the right to lighten the image. Our final GIMP image of the Crescent Nebula (see opposite) shows the success of our data stretch and brightness adjustment.

Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

△ Planetary nebula HFG1

Douglas Struble, Taylor, Michigan, USA, 10 November 2018 and 26 November 2020

Douglas says: "This planetary nebula in the constellation of Cassiopeia is one of the most challenging objects I've ever processed, even with over 90 hours of data. I think I've reached the limit for my aperture now, given the highly light-polluted skies here just outside Detroit."
Equipment: ZWO ASI 1600MM Pro camera, Stellarvue SVX102T-R and Explore Scientific 152mm apo triplet refractors, Astro-Physics GTO-Mach 1 and Orion Atlas Pro mounts
Exposure: 93.4h total
Software: SGPro, PixInsight, Photoshop

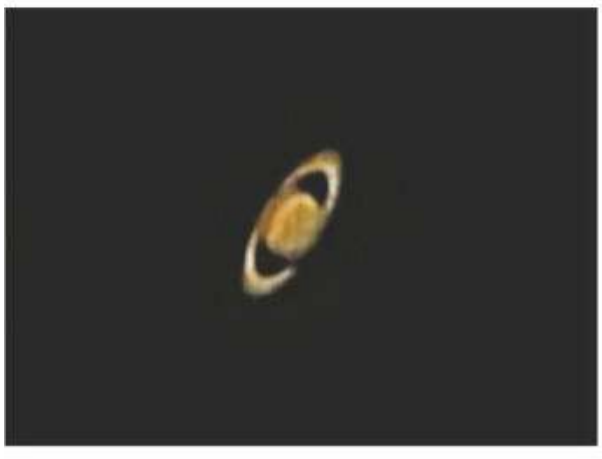
Douglas's top tips: "Planetary nebulae respond best to narrowband filters for Ha (Hydrogen-alpha) and OIII (Oxygen III). With my light pollution, a 7nm or 6nm Ha filter is typically fine, but for OIII I find a narrower band is best; I use a 3nm OIII Astrodon filter, which blocks moonlight and LED street lights. The icing on the cake is always adding stars captured in RGB; I gathered an hour on each channel. It's always best to capture RGB stars at the zenith (straight overhead) to minimise atmospheric distortion."

△ M81 Bode's Galaxy

Martina McGovern, Cambridge, 22 November 2020

Martina says: "I've recently turned to deep-sky objects and they're helping me through the challenging COVID-19 times. I stayed up until 6am to capture this one."

Equipment: ZWO ASI 294MC Pro camera, Celestron Edge HD 8-inch Schmidt-Cassegrain, Sky-Watcher HEQ5 Pro mount **Exposure:** 5h total **Software:** DeepSkyStacker, PixInsight, Photoshop



△ Saturn

Lauren Hodgson-King, Leigh-on-Sea, Essex, 13/14 September 2020

Lauren says: "This is my first attempt at planetary imaging, so I'm really pleased with the results."

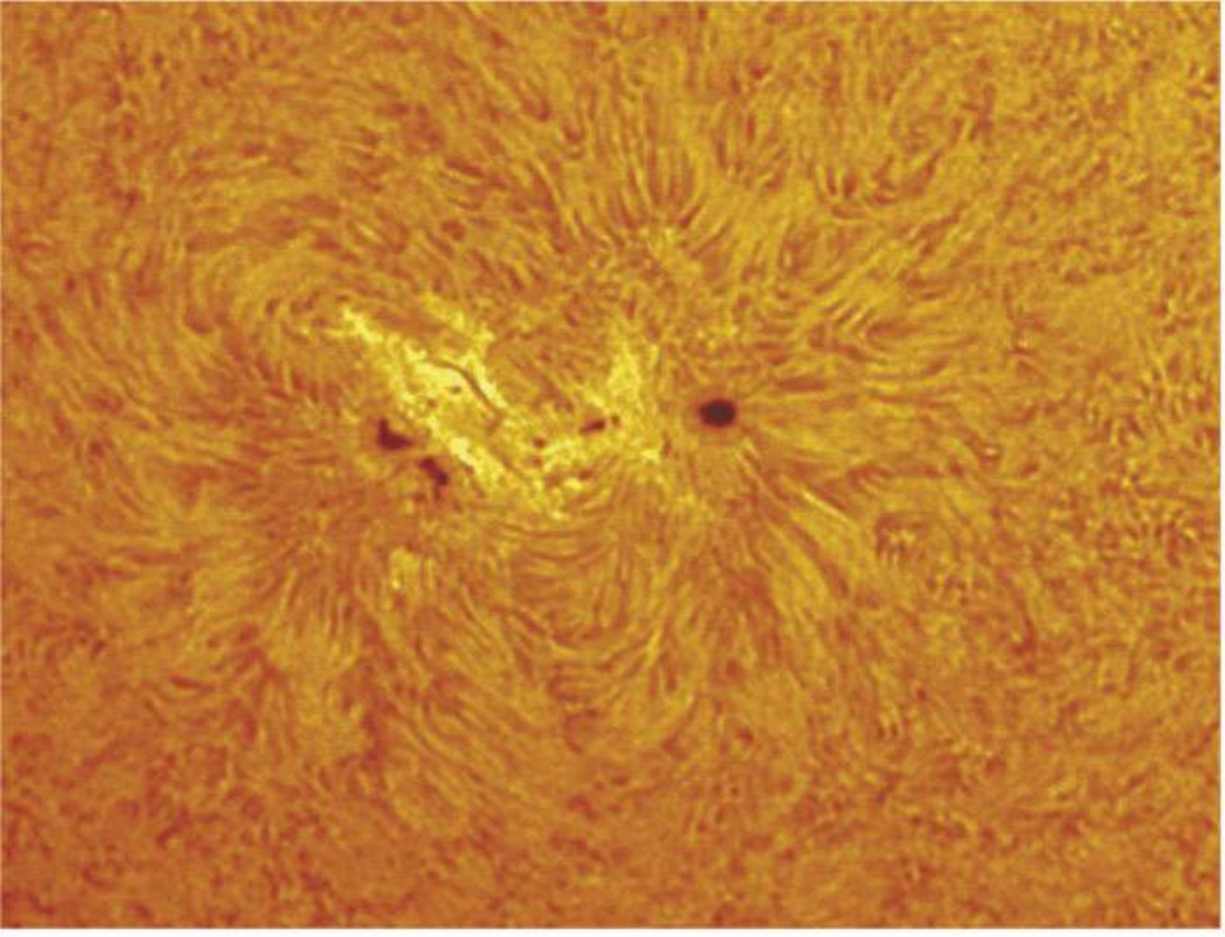
Equipment: Celestron NexImage Burst colour camera, Celestron NexStar 6SE Schmidt-Cassegrain **Exposure:** 25fps, gain 60 per cent, 1,891 frames, 100 stacked **Software:** RegiStax, Affinity Photo

△ Sh2-112 in Cygnus

Herwig Peresson, Vienna, Austria, August 2017 – November 2020

Herwig says: "This is a combination of Ha, OIII and RGB frames taken over seven nights between 2017 and 2020, from the centre of Vienna."

Equipment: Atik One 6.0 mono CCD camera, Sky-Watcher Quattro f/4 Imaging Newtonian modified by Lacerta, 10 Micron GM1000 HPS mount **Exposure:** 29.7h total **Software:** PixInsight, Photoshop



△ Sunspot group AR2781

John Chumack, Dayton, Ohio, USA, 28 November 2020

John says: "Although we're still at solar minimum, it's so nice to see the Sun producing sunspots and flares in the new Solar Cycle 25. Solar maximum should occur in July 2025, so it should just get better from here on."

Equipment: QHY5III290M CMOS camera, Lunt 60mm H-alpha solar telescope, Paramount MyT mount **Exposure:** 35fps, 1.116ms, gain 302, 1,383 frames, 735 stacked **Software:** FireCapture, RegiStax

▽ Great Conjunction of Jupiter and Saturn

Prabhu S Kutti, Sharjah, UAE, 21 December 2020

Prabhu says: "Light-polluted skies make it difficult to capture Jupiter and Saturn's faint moons. As my horizon was too polluted for a good image, I had to drive to a dark location where I found a small mountain. Watching the gas giants and their moons with Earth in the foreground was truly a spectacle!"

Equipment: ZWO 1600mm camera, Sky-Watcher Esprit 80mm apo refractor, Sky-Watcher AZ EQ6 mount **Exposure:** Gain 139, 5" **Software:** PixInsight, Photoshop

△ Moon, Venus and Spica

James Coard, Lisburn, 13 November 2020

James says: "I noticed this out of my window just before sunrise. The Moon lit up by earthshine made the scene a bit more special to my eye."

Equipment: Sony A7III mirrorless camera, Tamron 28–75mm lens, tripod **Exposure:** ISO 800 f/4, 0.8" **Software:** Photoshop

△ The Jellyfish Nebula

Chris Bulik, San Antonio, Texas, USA, 15–17 November 2020

Chris says: "I used narrowband filters because of the faintness of this nebula. I was very pleased with the detail I was able to bring out of what would otherwise be invisible to the naked eye."

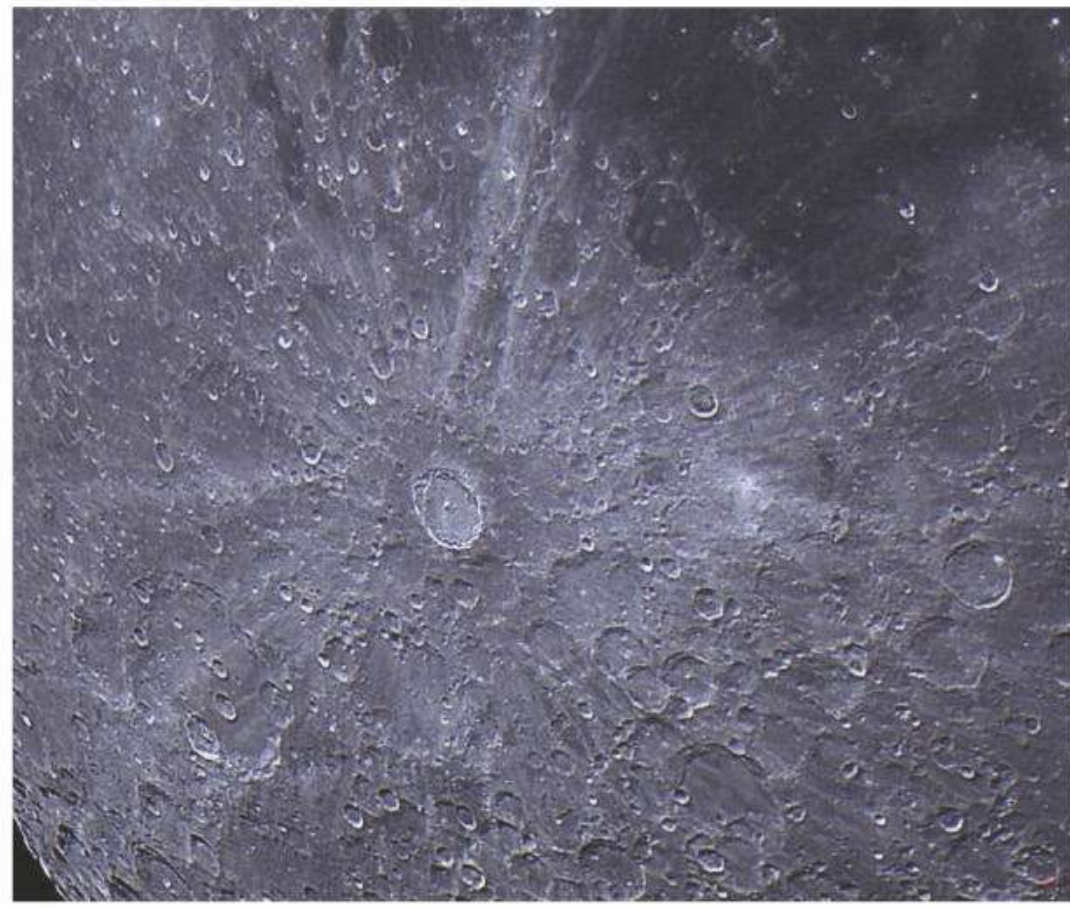
Equipment: ZWO ASI 294MM Pro camera, Meade 70mm apo refractor, Sky-Watcher EQ6-R Pro mount **Exposure:** Ha 40x300", OIII 40x300", SII 40x300" **Software:** Photoshop, PixInsight, Topaz DeNoise, Astro Pixel Processor

Crater Tycho ▷

Steve Fox, Camberley, Surrey, 3 November 2020

Steve says: "I've called this 'Splat!' – using RGB filters gave a 'colder' look than just mono, which I quite like."

Equipment: ZWO ASI 120MM mono camera, Celestron EdgeHD 9.25-inch Schmidt-Cassegrain, Celestron CGX mount **Exposure:** 1,200 frames at 20fps, 50 per cent-stacked **Software:** FireCapture, AutoStakkert!



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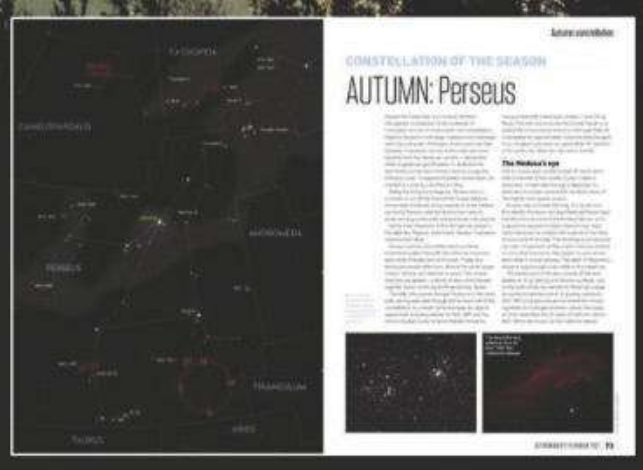

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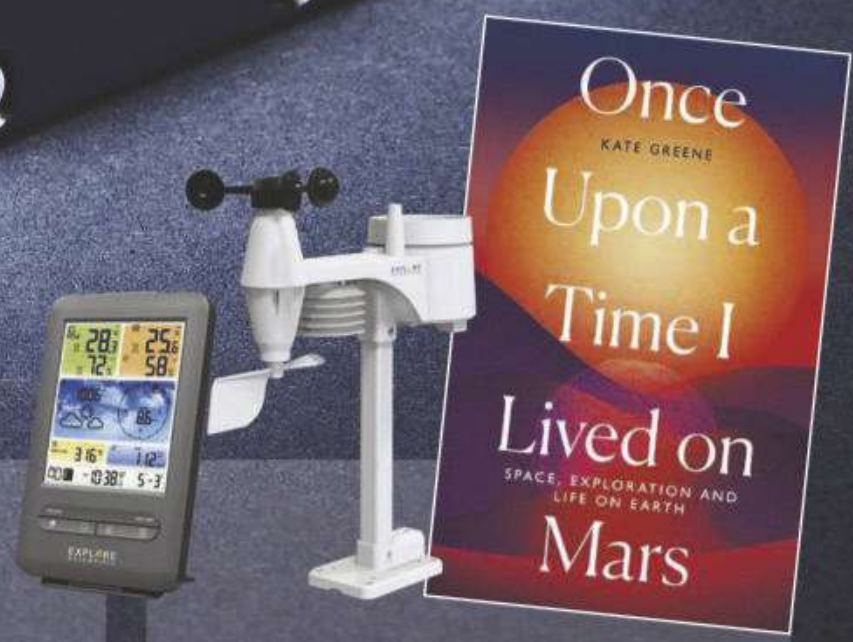
86
Best of both worlds? We test the Atik ACIS 7.1 CMOS mono camera on deep-sky and Solar System targets



HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

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@THESHED/PHOTOSTUDIO

Atik ACIS 7.1 CMOS mono camera

A high-performing CMOS model that balances deep-sky and Solar System imaging

WORDS: TIM JARDINE

VITAL STATS

- **Price** €2,145
- **Sensor** Sony IMX428 monochrome
- **Sensor size** 3,208 x 2,200 pixels
- **Pixel size** 4.5µm x 4.5µm
- **Power** 12V DC, 2.5A (not supplied)
- **Size** 82mm x 82mm x 64mm
- **Weight** 0.53kg
- **Supplier** Rother Valley Optics Ltd
- **Tel** 01603 740397
- **www.atik-cameras.com**

Atik has recently introduced a range of three ACIS cameras – the name standing for Advanced CMOS Imaging Systems. The cameras are designed to provide a variety of high-quality scientific imaging applications, which for our purposes makes them highly suitable for astrophotography. The model we are reviewing is the monochrome version of the Atik ACIS 7.1 CMOS, a 7.1 megapixel camera. The build quality of the ACIS 7.1 is very impressive, as we'd expect from a camera designed for professional use; it's a chunky, solid little unit that is stylishly machined, has no rough edges or flimsy fittings and appears to be very well made.

To begin the review, we combined the camera with our 1.25-inch filter wheel and mounted it on our 6-inch imaging refractor, a Sky-Watcher Esprit 150ED. The ACIS 7.1 can be controlled using Atik's own imaging software, either Artemis Capture or Dusk, and we had a quick session with these programs, while getting to grips with the camera, but eventually settled on the software we are most familiar with, controlling it via the latest ASCOM drivers (ASCOM is an industry-standard interface that allows different pieces of astronomical equipment to communicate). Our first clear night was graced by one of the highest Moons of the year, which gave us a chance to see how fast the camera could perform on planetary targets. After letting the regulated cooling system settle for a few minutes to a useful –15°C we slewed the telescope to favourably positioned Mars, and later to the Moon.

All-round appeal

The ACIS 7.1 has three power settings and we selected 'Fast Mode' for planetary imaging, which lets the camera take advantage of the onboard DDR memory for streaming images. With a USB 3.0 connection and using the Dusk application on our laptop, we managed to achieve 15 frames per second in full-frame mode, jumping massively to 175fps with a 640 pixels x 480 pixels region of interest setting. Cameras that bridge the gap between having speed for planetary imaging and quality for deep-sky object work offer the user a single solution to most astronomical targets; the Atik ACIS 7.1 ticks both boxes and represents a good option as an all-round camera.

There is often some confusion around CMOS cameras as to what gain and offset settings should be applied. While offering advanced users the option to configure these as desired, we liked the Atik 7.1's ▸

Sensor with a sharp memory

As CMOS technology progresses, we are starting to see cameras that can rival, and in some cases surpass the abilities of their CCD-sensor forerunners, especially as regards sensitivity. The Sony IMX428 sensor used in the ACIS 7.1 has a low dark current, keeping fixed pattern noise to a minimum, which reduces unwanted artefacts. Unlike CCD-based cameras, CMOS sensors are generally affected by what is often referred to as 'amp glow', a dated and technically incorrect term that describes the various glow artefacts that can appear on the edges of images. Atik has used an onboard 256Mb DDR3 memory buffer to minimise these electronic artefacts, which you'll see as a diffuse soft glow. This unavoidable glow, along with the fixed pattern noise is easily removed by applying dark frames taken at a matching temperature to the main exposures. For those who enjoy the technical details, the camera has a 12-bit ADC (analogue-to-digital converter), a pixel size of 4.5µm x 4.5µm, a well depth of 20,000e- mapped to a pixel value of 65,535 and a low readout noise of 3e- at low gain.

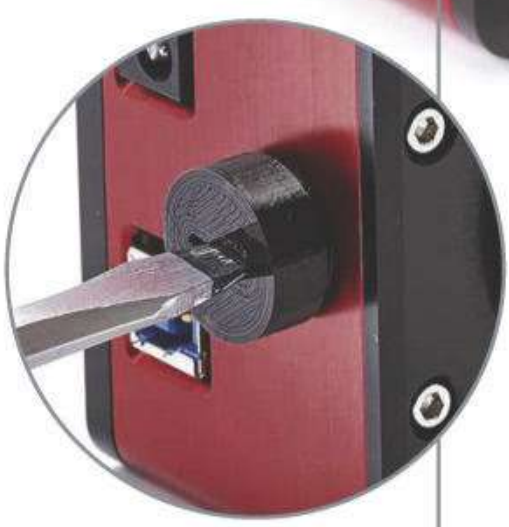
ALL PICTURES: @THESHED/PHOTOSTUDIO

Build quality

The body of the camera measures 82mm x 82mm x 64mm and is exquisitely machined and finished with Atik's trademark red anodising. The optical window is quartz, with anti-reflection coatings on both sides. The cap over the optical window is aluminium and it screws safely into the M42 x 0.75mm thread.

Cooling system

The electronic cooling system uses two quiet fans to pull air through the camera, across the heat sink, and out the other side. Cooling to –35° below the ambient temperature is achievable, making it easy to take temperature-matched exposures, night or day.



Desiccant port

Cooled astronomy cameras in moist atmospheres can be prone to developing dew inside the camera housing, especially on the inside of the optical window, which is a real nuisance. This is solved with a rechargeable and replaceable desiccant tablet that's housed within the casing, which can be removed with a screwdriver and the included tool.

Connectivity

While you can use the USB 3.0 connection for fast data transfers over the supplied good quality USB 3.0 cable, the camera can also be used with a USB 2.0 cable if needed. This allows users to take advantage of existing cable runs in observatories, or longer cable connections than allowed by USB 3.0.

▲ A stunning image of M31, captured by the Atik ACIS 7.1 camera and a Sky-Watcher Esprit 150ED scope

▲ The Merope Nebula in an hour of 3' exposures, plus 15' each of Red, Green and Blue filtered shots

ALL PICTURES: TIM JARDINE

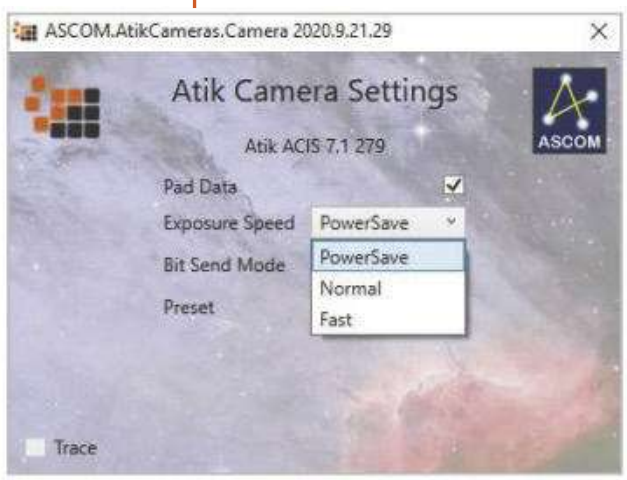
▸ straightforward standard gain options of 'Low', 'Medium' and 'High' that make the camera suitable for beginners too. We opted to use the 'Low' setting for the majority of our targets as this provides the most detail overall, while switching to 'Medium' or 'High' for taking narrowband exposures that need a bit of help with fainter objects.

Choosing the Andromeda Galaxy, M31, as an initial deep-sky object target gave us the chance to see how the camera performed on an object with both very bright and very faint regions. We took a series of five-minute exposures for each filter. The core of M31 was not blown out, which preserved detail, while the fainter, more subtle dusty areas were nicely revealed (see image, top). We were pleased to see that amp glow is minimal in the ACIS 7.1, and once correctly matched dark frames were applied to our stacked images, there was no trace of amp glow artefacts. Moving on to the Merope Nebula in M45 (see image, above), it allowed us a chance to see how the camera handles bright stars against faint reflection nebulosity. Once again the results were very pleasing, with lots of detail in the intricate dust patterns and good control of the bright stars.

For a narrowband target we chose the Horsehead Nebula (above) and used an Ha (Hydrogen-alpha) filter. The results from a series of five-minute exposures in 'High' gain mode were also very impressive and demonstrated the ability of the camera to capture quality photographs of pretty much anything, from very bright to extremely faint.

Overall, the Atik 7.1 is a well made, high-performing CMOS camera that will appeal to deep-sky and Solar System astrophotographers alike.

Three power modes



The ACIS 7.1 offers three power modes – 'PowerSave', 'Normal', and 'Fast'. In 'PowerSave' mode, minimal electronics are used during image capture to allow the highest quality images to be taken, while 'Fast' mode makes best use of the onboard DDR3 memory buffer for planetary or lunar imaging applications.

▲ The Horsehead Nebula – as captured with the Atik ACIS 7.1, Sky-Watcher Esprit 150ED, Atik EFW2.2 filter wheel and Baader 1.25-inch filters – using 22x 5' Hydrogen-alpha (Ha) exposures

VERDICT

Build & Design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★½
Features	★★★★½
Imaging quality	★★★★★
OVERALL	★★★★½

KIT TO ADD

1. Atik EFW2.2 filter wheel

2. Atik LRGB filter set

3. Atik narrowband filter set

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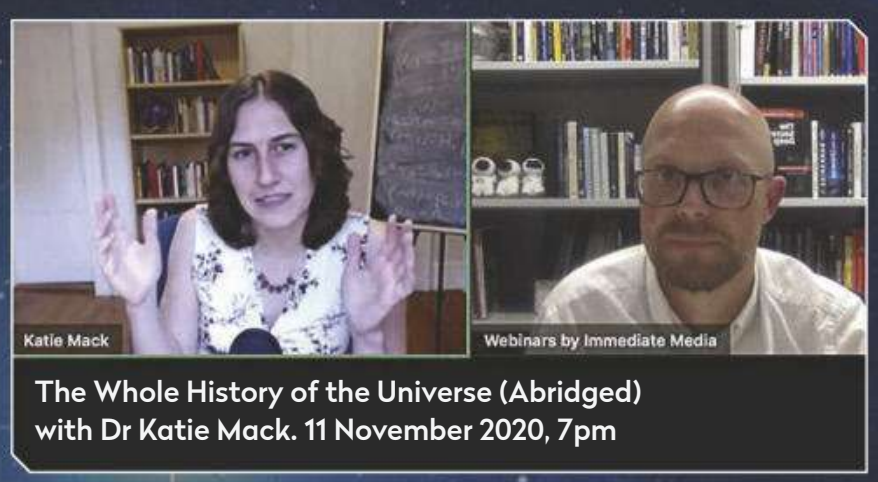

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FIRST LIGHT

Sky-Watcher Star Discovery P150i Wi-Fi telescope

An easy to use telescope with built-in Wi-Fi to assist control

WORDS: PAUL MONEY

VITAL STATS

- **Price** £459
- **Design** Newtonian altaz, Go-To, Wi-Fi-controlled telescope
- **Optics** 150mm (6-inch) parabolic primary mirror
- **Focal length** 750mm, f/5
- **Mount** Wi-Fi, computerised, altaz, single-fork arm
- **Ports** Power connector, camera, hand-controlller, integrated Wi-Fi adaptor
- **Tracking rates** Sidereal, Lunar and Solar
- **Tripod** Adjustable with accessory tray
- **Extras** Red dot finder, 25mm and 10mm 1.25-inch fit eyepieces, bubble level
- **Weight** 8kg
- **Supplier** Optical Vision Ltd
- **Tel** 01359 244200
- **www.** opticalvision.co.uk

Today we are seeing a quiet revolution taking place as more telescopes are being given Wi-Fi control, allowing the modern generation of mobile and tablet users the ability to control their telescopes with their devices. Sky-Watcher introduced the Star Discovery a couple of years ago supplied with a separate dongle for Wi-Fi connections, but here we take a look at the latest version of the telescope that has Wi-Fi integrated into the mount itself.

The Star Discovery P150i Wi-Fi comes in two boxes and is straightforward to assemble, allowing you to be up and running in 10 to 15 minutes. The tube assembly is in one box while the tripod, single-arm mount, spreader tray and a box with the eyepieces, finder and bubble level is in the second. It's best to assemble the mount onto the tripod first and then to attach the telescope, before completing it with the red dot finder.

The mount is powered either by eight AA batteries installed in the side of the mount, or via a 12V power tank plugged into the power port. We used the system for several hours with batteries on three occasions and had no trouble, proving this is an easy system to set up, which can be taken anywhere.

The red dot finder is a zero-magnification, no-nonsense piece of kit that can be used during the alignment process, but once it is aligned with the main telescope you'll find it's hardly needed at all. Two eyepieces are supplied, of 25mm and 10mm focal length – the usual combination at this price level. As the 6-inch primary mirror is a 150mm-diameter parabola and the scope's focal length is 750mm, the 25mm eyepiece gives a magnification of 30x, while the 10mm gives a magnification of 75x. These are good choices for this system, giving nice views of deep-sky targets and the Moon. If you add a 2x Barlow lens (not supplied) you can get reasonable views of the brighter planets as well.

Getting connected

Once the Star Discovery P150i Wi-Fi telescope was switched on we connected it to our smartphone and the SynScan app (iOS and Android versions available) ▸

Easy to use Wi-Fi control

One of the first things you notice about this Star Discovery telescope is that there is no hand-controller – although the mount does have a port for connecting one. You don't need a separate controller with this scope because it is operated with an app, connected via the inbuilt Wi-Fi network. To use it we turned on the power and the mount automatically generated a Wi-Fi network, allowing us to connect our smartphone and later our tablet. Once connected, you ownload the SynScan or SynScan Pro app (we used the Pro version) and run it. There are plenty of observing options in the app, including alignment routines, and Solar System and deep-sky targets.

The SynScan app (right) may not look fancy, but it certainly did the job and allowed us to slew to a wide range of targets with ease. For those who like to use the popular SkySafari app for Go-To control on iOS devices, the good news is that you now don't need to have two devices: by choosing 'SkyWatcher SynScanLink' in the telescope settings menu, you'll be able to connect to SkySafari easily and control the mount through that app.

@THESHED/PHOTOSTUDIO X 4, PAUL MONEY

Single-arm Go-To altaz mount

The single-arm mount is solid and well made, fitting neatly into the tripod base and held in place with three knobs. The mount has a Vixen-style saddle for attaching the telescope and a good retaining knob for securing the tube firmly in place.

Tripod

The tripod is sturdy with telescopic aluminium legs that can be easily extended – though they spread quite wide at full extension and may be a trip hazard in the dark. The spreader tray can hold both 2-inch and 1.25-inch eyepieces, although only the latter can be accommodated in the telescope's focuser.

SCALE

Optics

The Star Discovery 150i is a Newtonian telescope design, with a 150mm parabolic primary mirror and a secondary mirror attached at the front via a spider vane. The 'short' focal length of 750mm gives a focal ratio of f/5 that works well for both planetary and deep-sky viewing.

Ports and battery compartment

The mount incorporates an on/off switch and ports for an external 12V power pack, a camera and an optional SynScan handset, although this shouldn't be needed with the Wi-Fi control. There's also a compartment for eight AA batteries, giving a more portable power option.

FIRST LIGHT

KIT TO ADD

1. Sky-Watcher 7Ah power tank

2. Sky-Watcher Deluxe 2x Barlow lens

3. OVL lunar and planetary filter set

▸ and then we set the telescope to level and pointed it north using the bubble level and compass. We performed a one-star alignment on Aldebaran (alpha (α) Tauri) and found most of our targets somewhere in the field of view of the 25mm eyepiece. A more accurate alignment – using either two or three stars – greatly improved the pointing accuracy and placed most targets close to the centre of the view.

Target practice

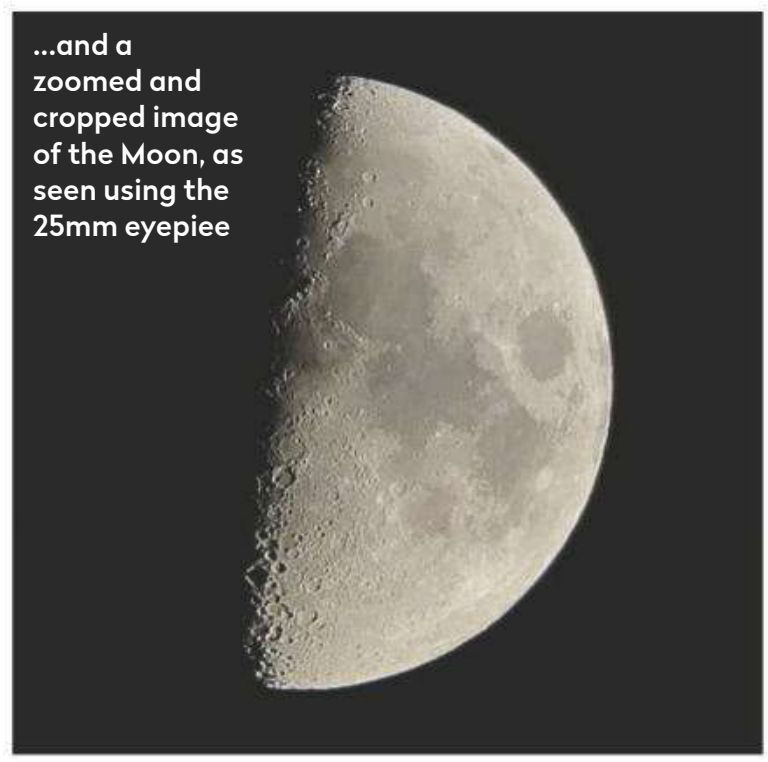
The field of view quality with the 25mm eyepiece showed Rigel (Beta (β) Orionis) as sharp across 70 per cent of the view, so we selected the colourful double star Albireo (Beta (β) Cygni) and were rewarded with a pin-sharp view of the golden and blue pair, nicely separated. We found that by swapping to the 10mm eyepiece, we had an even better view, with a stronger contrast of colours on display. Meanwhile, the galaxy pair of M81 and M82 filled the centre view of the 25mm eyepiece and just fitted in the view of the 10mm eyepiece. The Pleiades star cluster sparkled in the 25mm eyepiece and the Double Cluster in Perseus particularly impressed us – not just because of the views of its members, but because of the subtle views of the orange stars scattered between them. The Orion Nebula was stunning, with a higher magnification revealing the Trapezium Cluster at its core.

When it came to Solar System objects, only Mars and the Moon were easily available at the time of the review, but by adding a 2x Barlow lens to the 10mm eyepiece we could make out albedo features and a polar cap on the Red Planet. We were also pleased to discover that you can spend a long time exploring the detail of the Moon's features with this system.

Although the Star Discovery 150i is not meant for astrophotography, we added our own smartphone holder and used our iPhone XR and the 25mm eyepiece to image the Moon, the Pleiades and the Orion Nebula, adding to our enjoyment of this telescope. We can certainly recommend the Star Discovery 150i for those bitten by the astro bug!

▲ **The Pleiades, captured through the Sky-Watcher Star Discovery P150i Wi-Fi, using an iPhone XR with a smartphone adaptor to take a 1" exposure at ISO 4608**

◂ **The Sword of Orion, taken with the same setup, using a 6" exposure at ISO 1600...**



...and a zoomed and cropped image of the Moon, as seen using the 25mm eyepiee

Focuser and finder

The red dot finder is useful for the initial alignment phase of operation; the focuser is a standard rack and pinion style that takes 1.25-inch eyepieces. Two of these are provided, of 25mm and 10mm, giving magnifications of 30x and 75x, which are suitable choices for the size of telescope.

VERDICT

Assembly	★★★★★
Build & design	★★★★½
Ease of use	★★★★★
Features	★★★★½
Optics	★★★★½
OVERALL	★★★★½

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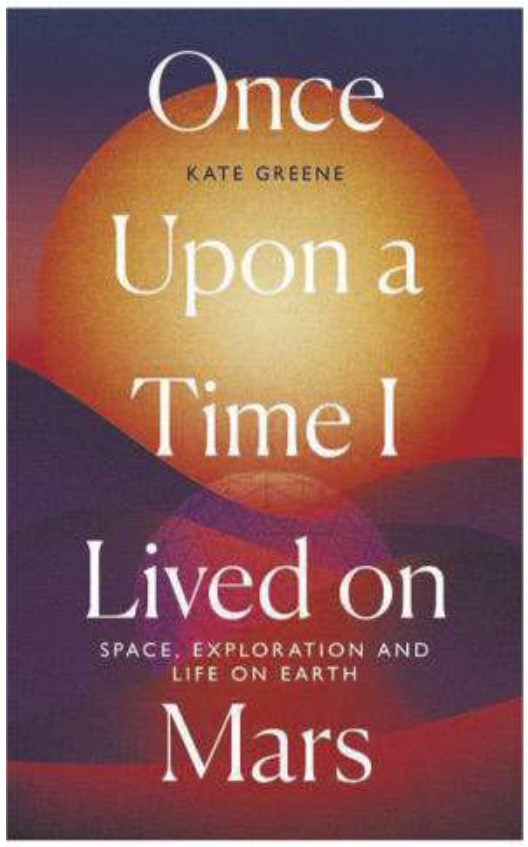

Once Upon a Time I Lived on Mars

Kate Greene
Icon Books
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HI-SEAS (Hawaii Space Exploration Analog and Simulation) is a geodesic dome isolated on the slopes of Mauna Loa, a volcano on Hawaii's Big Island. From 2013 to 2018 it was used by NASA for six 'analog missions' – field tests in locations that have physical similarities to space environments – to Mars. Crews of 'almost astronauts' remained in complete isolation for up to a year, in conditions as close as possible to those expected of a small crew on the Red Planet.

This book follows the first of those missions, which took place over four months in 2013 and which studied, among other things, the role that food resources would play on a long-term mission. The crew of six were cut off from the world, with a 20-minute delay imposed on communications with Mission Control, no social media and limited email contact with family. They ate a combination of ready-made meals and ones that they cooked for themselves, carried out experiments and other studies, and went outside on EVAs in mock spacesuits on the Mars-like slopes of the volcano.

Rather than present a day-by-day account of the mission, Greene uses various aspects of the mission to explore wider issues in our lives, such as the role food plays, the problems of boredom and communication, the part of the human guinea pig and the effects of isolation.

It is a timely book that resonates strongly when many of us have been forced into solitary isolation or been cooped up with family for extended periods due to COVID-19 lockdowns – the things we miss, the minor niggles that can so easily build into major conflict when living in close proximity and privacy is at a premium.

▲ **Dr Yajaira Sierra-Sastre admires the sunset during the 2013 HI-SEAS simulated space mission**

DR. SIAN PROCTOR/HI-SEAS

The writer skips between historic accounts, personal anecdotes, inner musings, scientific research and the daily routine of the mission. This makes the writing very human, like an internal monologue, but can lend the writing a jerky style at times, lacking flow. There are a lot of questions asked, but the reader is often left to find their own answers and draw their own conclusions, which is perhaps no bad thing. ★★★★☆

***Jenny Winder** is a freelance science writer, astronomer and broadcaster*

Interview with the author
Kate Greene

What was a typical day like at HI-SEAS?

We'd eat breakfast together, have our morning meeting and then get to work on our own research projects, completing surveys and performing tasks for other research studies, chores and maintenance – answering emails, that kind of thing. We exercised in groups of two during the day, at least 45 minutes five days a week. We'd eat lunch together and then went on EVAs, wearing simulated spacesuits to collect rocks for geology experiments. After eating dinner together, we'd supposedly relax, but we'd often catch up on work and emails. On Wednesday and Saturday nights we watched movies.

What did you enjoy and hate about it?

I enjoyed the experience of stepping out of capitalism for four months because on Mars we had everything we needed: there's no need to think about buying toilet paper, for example! I loved getting to know my crewmates and escaping social pressures to hang out, which is a lot like what's happening now during the pandemic. There were things I missed, like real-time conversations with loved ones, or swimming, or sunlight on my skin, but it was only four months and I didn't really hate anything.

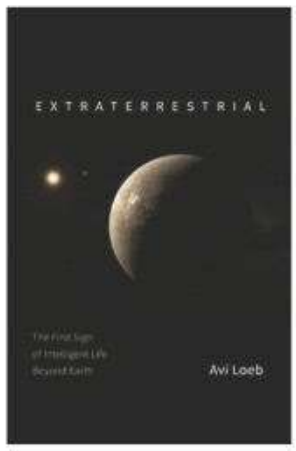
If you could be on the first trip to Mars tomorrow, would you go?

I don't think so. There's still much to be done to make sure the endeavour would be safe and well-designed; it'll take a lot of money, concerted effort and years if not decades. Even then, it's a long journey, far away from a beautiful planet that I like to spend time on – but maybe on the fifth trip.

***Kate Greene** is a journalist, former laser physicist and was second-in command on the first simulated HI-SEAS Mars mission*

Extraterrestrial

Avi Loeb
John Murray Press
£20 ● HB



When I saw the synopsis of *Extraterrestrial* I thought I was about to read the kind of book that stereotypically comes written in green ink. The author, however, is Professor Avi Loeb, a renowned astrophysicist with a history of dabbling in many research areas, often before they became 'mainstream'.

The hypothesis presented in this book is that 'Oumuamua – the interstellar visitor that whizzed through our Solar System in late 2017 – was technology from another intelligent civilisation. It's true the object is very unusual in a number of ways and hard to explain using models of 'normal' comets or asteroids, but the hypothesis is (unsurprisingly) controversial.

The book is autobiographical to some degree and doesn't shy away from Loeb's many academic accomplishments (many superfluous). It's largely non-technical: if you want the maths, look at the 'further reading' or take Loeb's word for it.

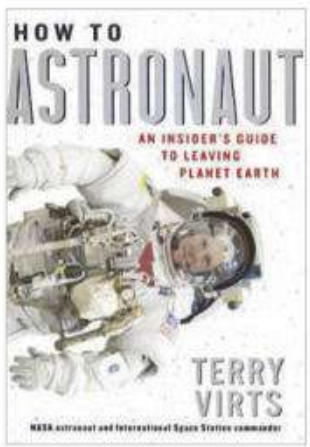
After describing the oddities of 'Oumuamua and disposing of conventional explanations, Loeb puts forward justification for his theory. There follows much speculation about what might motivate an extraterrestrial intelligence to build such a spacecraft, how we might seek out more, and what implications the discovery could have. While it leaves the laws of physics intact, there is a lot of pure speculation.

Be warned: don't expect a balanced debate over whether 'Oumuamua was alien. This is more of a manifesto for what humanity should do under the assumption that it is. I leave it to you to decide whether to believe the arguments.
★★★☆☆

***Dr Chris North** is the Odgen Science Lecturer and STFC public engagement fellow at Cardiff University*

How to Astronaut

Terry Virts
Workman Publishing
£16.99 ● HB



The most stressful thing that F-16 pilot, NASA astronaut and space walker Terry Virts has ever done in his life was cutting crewmate Samantha Cristoforetti's hair, in weightlessness, onboard the International Space Station (ISS). It's one of many fun anecdotes in this very personal account of what it's like to be an astronaut.

Virts has been in space twice, commanded Expedition 43, helped shoot the IMAX movie *A Beautiful Planet*, carried out three spacewalks, and happens to be a talented writer, too. In 51 brief chapters he takes his readers from training programmes, launch ("If I had to summarize the experience in one word, it would be: Wow!"), activities – and nuisances – in orbit, and back to re-entry.

Peeing in a diaper, carrying out housekeeping chores, meticulously unpacking a cargo ship, or experiencing a Soyuz landing ("a crash is exactly what it felt like") may not appeal to everyone, but Virts loves every amazing thing he does, and his enthusiasm certainly makes for an enjoyable read, with lots of behind-the-scenes information – and loads of NASA acronyms.

My favourite chapter is 'Where over the world are we', with great descriptions of the wonderful views of our home planet from the ISS's Cupola viewport, which Virts helped install in 2010. Rather less impressive are the author's somewhat unscientific views on cosmic and biological origins, expressed in the penultimate chapter.

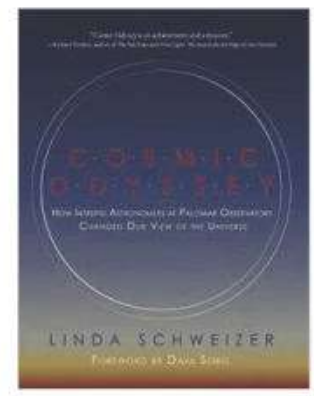
With space tourism around the corner, *How to Astronaut* may prepare future spacefarers for their first out-of-this-world experience, but homestayers will certainly love this book, too. ★★★★☆

***Govert Schilling** is a science author and journalist*

Cosmic Odyssey

PACKED WITH FACTS

Linda Schweizer
MIT Press
£32 ● HB



Sitting atop Palomar Mountain in San Diego county, California, Palomar Observatory is one of the most famous observatories in the world. In *Cosmic Odyssey*, Linda Schweizer has perfectly encapsulated its rich history and astonishing discoveries in a book which will thrill astronomers and engineers alike.

With a grant of $6 million, astronomer and telescope-maker George Ellery Hale established the observatory in 1928, and from the opening chapter Schweizer details Hale's journey and his determination to construct a 200-inch telescope. In 1948, this colossal telescope was the world's biggest. Palomar's iconic building, owned and operated by Caltech, has become one of the world's most successful observatories. Schweizer tells the story flawlessly.

Schweizer uses her meticulous research and interviews to open our eyes and minds to the ground-breaking and remarkable research undertaken at the observatory, and the people who worked tirelessly to discover and unravel some of the biggest mysteries of the Universe. From 'Canaries in a Coal Mine' to 'The Spaghetti Factory', the concise, enticing headings within each chapter really grasp the reader's attention, enticing us to keep reading.

Schweizer has combined her detailed text with glossy photos, sketches, boxouts and diagrams. While some hardback astronomy publications can be oversized and cumbersome, Schweizer's easy-to-handle hardback takes it from a 'coffee table flick-through' book to a 'pick up, take anywhere and delve in' title. So, during a time when travel is restricted, sit back and allow yourself to be transported to this beautiful art deco observatory and deep into the Universe. ★★★★★

***Katrin Raynor-Evans** is an astronomy writer and a fellow of the Royal Astronomical Society*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 SanDisk Extreme Pro SD card

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Astrophotography requires lots of large images recorded in a raw format. With these SD cards, ranging up to 512GB, you'll have more than enough storage to last you through the night.

2 Explore Scientific weather centre

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Continuously keep track of your local atmospheric conditions and make sure you never miss out on another clear sky with this digital weather device.

3 Primaluce Lab EAGLE4 advanced control unit

Price £999 • **Supplier** 365 Astronomy
Tel 020 33 845 187 • **www.365astronomy.com**

ADVANCED This little box contains everything you need to streamline your astrophotography setup. The EAGLE4 is a computer that can be loaded up with all your favourite software and then used to connect all your devices with its eight USB and seven power-out ports. The system then links to your control device via Wi-Fi.

4 Pegasus FocusCube 2

Price £250 • **Supplier** Widescreen Centre
Tel 01353 776199 • **www.widescreen-centre.co.uk**

Temperature changes and moving targets can cause your setup to lose focus, but this motorised device will help keep your images crisp by automatically re-focusing as you go. Connects to your PC via a USB cable, and can hold up to 6kg of imaging equipment.

5 Mae Jemisox socks

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www.chattyfeet.com

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6 NASA Space Rocket kit

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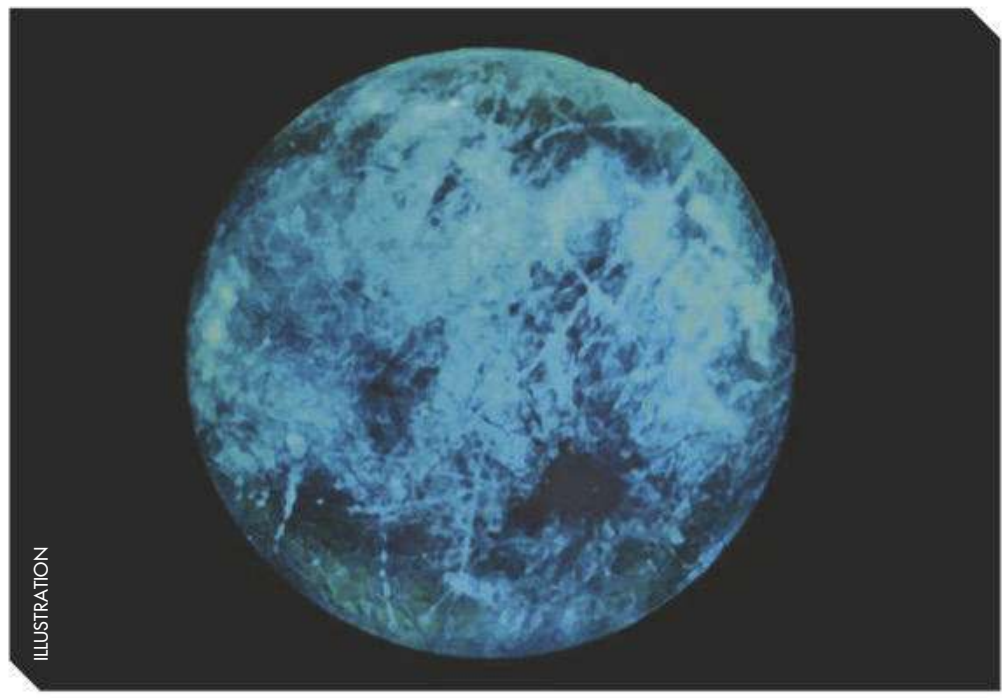
Shaoni Bhattacharya interviews Murthy Gudipati

Q&A WITH A SPACE ICE EXPERT

Studying Europa's potential habitability led to the serendipitous finding that Jupiter's moon may "glow in the dark"

Why did you and your NASA colleagues study Europa?
Europa is thought to have liquid oceans in its interior covered by very cold ice, which is in contact with its rocky core and absorbs minerals. There is also an expansion and contraction of Europa taking place because of the tidal force of Jupiter, so there is energy being generated inside. As we know, for life we need minerals, water, energy and organics, and as these things seem to be available on Europa, people think its interior could be habitable.



ILLUSTRATION

▲ **Night glow: scientists have discovered that the ice on Jupiter's moon Europa's is glowing due to being bombarded by electrons**

Tell me about the research that led to your recent study in the journal *Nature Astronomy*.
Europa is in a unique situation, as one of the four big Galilean moons around Jupiter – a planet with a very strong magnetic field. Because of this and because Io, the closest moon, has extremely high volcanic activity, you get ions and electrons generated and accelerated by Jupiter's magnetic field, meaning Europa's surface gets a very high dose of radiation. So while the interior could be habitable, the surface is absolutely not.

One of our original research aims was to understand how deep the electrons penetrate through Europa's surface; the deeper they go the more damage they could do, particularly to organic material. So our aim was to see how organic matter would be destroyed if brought up to the surface from the oceans.

How did you simulate Europa's conditions on Earth?
We needed an instrument that could hold several tens of centimetres of ice core close to 100K (–173°C), so we built the Ice Chamber for Europa's High-Energy Electron And Radiation-Environment Testing (ICE-HEART). We took it to the USA's National Institute of Standards and Technology in Gaithersburg, Maryland where they have a high-energy electron source. The experiment was contained in concrete and lead walls with sensors deployed, and to understand what was happening visually we also deployed a camcorder.

We set out to analyse data to determine how deep the electrons go and the secondary radiation [X-rays] coming out. The primary goal was to understand this, and also how the frozen ice-salt mixtures differ from pure water ice. The glow came as a surprise – as serendipity.

What did you see when you switched the lights off on the Europa simulation?
We saw that the area on the ice where the electrons were bombarding was glowing. From water ice we went to brine, but there was no glow; so we thought there was something wrong; we then went back to water and it was glowing. That was the "Aha" moment for us; we realised the glow was coming from the ice and it's somehow determined by the composition of the ice.

What are the implications for habitability?
If NASA's upcoming Europa Clipper mission is able to see effects similar to those we found, the observations would help us to determine the surface composition. Europa is supposed to have a young surface, which means that the surface to sub-surface exchange is happening within 50 to 60 million years. That is very young – our Moon's surface is billions of years old. So we can use the surface composition and model how it maps to the ocean composition. We cannot say about life, but based on determining the surface composition, particularly salinity, we can get estimates of ocean salinity. In turn, that could be compared to our own ocean salinity to see if it is conducive to life.

Dr Murthy Gudipati is a principal scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, USA

What colour is Europa's glow likely to be?
For colour, we probably need to use our imagination! We derived approximate colours based on the spectral distribution. For water ice, on average this looks like a whitish glow, but then magnesium sulphate has more glow into the red, and sodium sulphate also has some into the red, while other minerals have a stronger glow in blue. I would say Europa's expected to have a whitish glow with a bluish, greenish or red tinge – maybe like a mosaic if we have different compositions. When the Europa Clipper visits, about 10 years from now, it would be wonderful to see Europa's glow on its nightside.

NASA/JPL-CALTECH

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Spot the peak of the Alpha Centaurid meteor shower and enjoy a view of the stars in Orion's Belt

When to use this chart

1 Feb at 00:00 AEDT (13:00 UT)
15 Feb at 23:00 AEDT (12:00 UT)
31 Feb at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

FEBRUARY HIGHLIGHTS

The Alpha Centaurids is one of the few meteor showers that's exclusive to the Southern Hemisphere. Active from 31 January to 20 February, its peak is expected on the 8th. With a new Moon on the 12th, the evenings through to the early morning at peak offer dark skies. Although peak rates can be low (five per hour), it compensates by producing bright yellow or blue coloured fireballs that leave trains. The Alpha Centaurids radiant is close to Alpha (α) Centauri and Beta (β) Centauri.

STARS AND CONSTELLATIONS

The three distinctive Belt stars of Orion are possibly the most easily recognised asterism visible from anywhere in the world. From left to right (west to east) Mintaka (Delta (δ) Orionis), Alnilam (Epsilon (ε) Orionis) and Alnitak (Zeta (ζ) Orionis) are all hot stars (O or B spectral classes). Alnilam and Alnitak are blue supergiants and are only dimmed to second magnitude by distance, about 2,000 and 1,200 lightyears away, respectively.

THE PLANETS

The evening skies are sparse with only Mars and Uranus on offer, both setting close to 23:00 midmonth. Likewise, the morning offers little until dawn. After last month, Saturn then Jupiter appears out of the solar glow, rising around the start of twilight midmonth. Mercury follows these outer planets into the morning and catches up. Low in the early eastern dawn sky, these planets are seen passing Venus; Saturn is closest on the 6th with Jupiter and Mercury on the 14th.

DEEP-SKY OBJECTS

The naked-eye star Pi (π) Puppis, or Ahadi (RA 7h 17.1m dec. –37° 06') is a double, offering colour contrast with mag. +2.9 and +7.9 components, yellow and blue respectively, separated by 1 arcminute. Pi Puppis is also the brightest member of a large open cluster, Collinder 135. Its most distinctive feature is three mag. +5.0 blue stars (two close together) in a line forming an isosceles triangle with Pi Puppis, fitting in a 0.5° diameter circle.

Move 6° west of Collinder 135 to discover the globular cluster NGC 2298 (RA 6h 49.0m, dec. -36° 00'). It is fainter (at mag. +9.3) and smaller than many globulars with a halo only around 3 arcminutes across and a few scattered faint stars around the edge. The brightness rises quickly to a 2-arcminute core which plateaus, showing little further brightening near the centre.

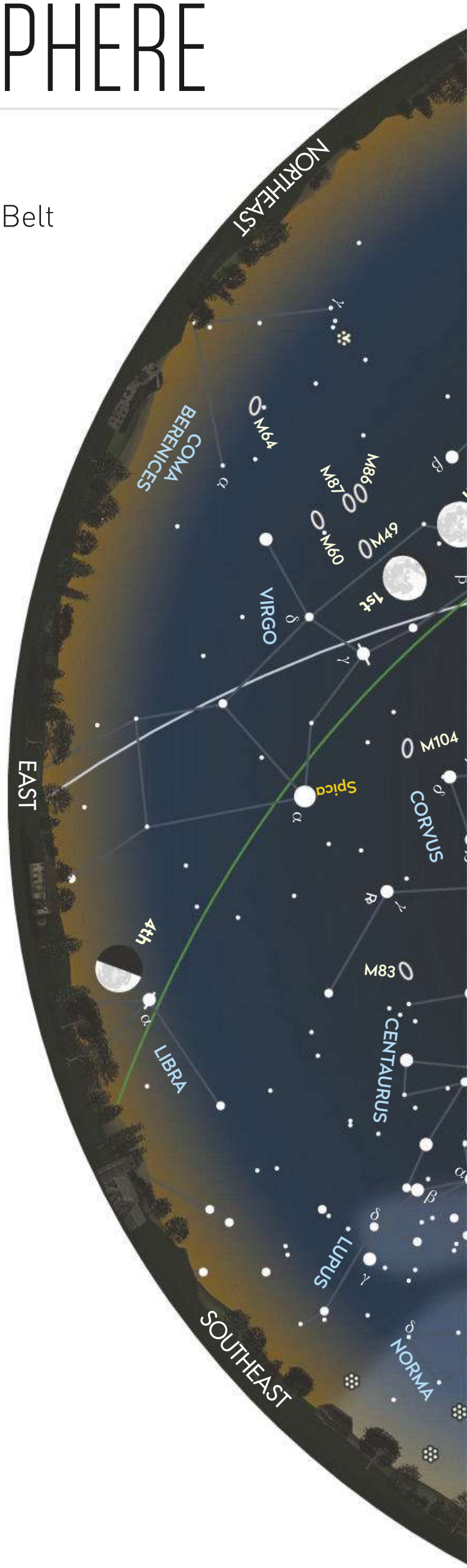

Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE

NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
LYNX
LEO MINOR
AURIGA
GEMINI
Castor
Pollux
M36
M37
M35
22nd
CANCER
M44 Beehive
LEO
Sickle
25th
Ecliptic
Regulus
M66
28th
CANIS MINOR
Procyon
Winter Triangle
Rosette Nebula
Betelgeuse
ORION
Aldebaran
Hyades
TAURUS
M78
Mirror of Venus
Celestial Equator
HYDRA
M48
MONOCEROS
M50
Sirius
M43
M42
Rigel
Alphard
M47
M41
CRATER
ANTLIA
Ghost of Jupiter
PYXIS
PUPPIS
CANIS MAJOR
LEPUS
Ahadi
Cr 135
NGC 2298
ERIDANUS
Canopus
COLUMBA
CAELUM
VELA
Eta Carina Nebula
False Cross
CARINA
PICTOR
FORNAX
HOROLOGIUM
w Cen
CRUX
Jewel Box
Coal Sack
Acrux
NGC 2397
VOLANS
LMC
DORADO
Tarantula Nebula
RETICULUM
Alpha Centaurids Peak 08 Feb
MUSCA
CHAMAELEON
MENSA
Rigel Kent
Hadar
Achernar
CIRCINUS
HYDRUS
South Celestial Pole
APUS
OCTANS
SMC
47 Tucanae
PHOENIX
TRIANGULUM AUSTRALE
ARA
PAVO
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